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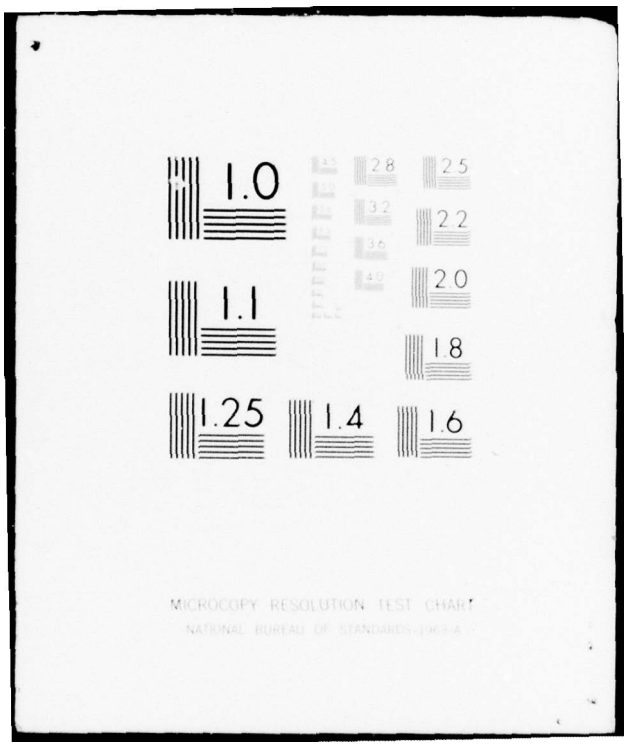
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APRIL to JUNE 1977

VOL. 2, NO. 2

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DEPARTMENT OF THE NAVY OFFICE OF NAVAL RESEARCH TOKYO

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COMPUTER	POLYETHYLENE	SHIPBUILDING
POLYMERS	MATERIALS	WELDING
PHOTORESISTS	METALLURGY	FATIGUE TESTING
CRYSTALLIZATION	MARTENSITE	CREEP TESTING

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This is a quarterly publication presenting articles covering recent developments in Far Eastern (particularly Japanese) scientific research. It is hoped that these reports (which do not constitute part of the scientific literature) will prove to be of value to scientists by providing items of interest well in advance of the usual scientific publications. The articles are written primarily by members of the staff of ONR

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19. KEY WORDS (CONT.)

CRACK PROPAGATION	ATHEROSCLEROSIS	SIMULATOR
SPACE RESEARCH	ENDOTHELIUM	PHYSIOLOGY
FLUID MECHANICS	LIPOPROTEINS	VIGILANCE
APPLIED MECHANICS	HYPERTENSION	MICROBIOLOGY
AERONAUTICS	CHOLESTEROL	MARINE SCIENCE
TURBULENCE	PSYCHOLOGY	THUNDERSTORMS
INDIAN SCIENCE	NEUROPHYSIOLOGY	HOKURIKU STORMS
COASTAL PROCESSES	EVOKED POTENTIALS	ELECTRIC FIELD
SEA WALLS	BULLET TRAIN	MYTHOLOGY
EROSION	RAILWAY SCIENCE	TRADITION
COASTAL PROTECTION	INDUSTRIAL PSYCHOLOGY	

20. ABSTRACT (CONT.)

Tokyo, with certain reports also being contributed by visiting stateside scientists. Occasionally a regional scientist will be invited to submit an article covering his own work, considered to be of special interest.

GUEST CONTRIBUTORS TO THIS ISSUE

Nicholas T. Werthessen is the bioscientist at ONR Boston. He trained under the late Gregory G. Pincus, who directed the development of the "Pill." Thus he specialized in endocrinology until the late 1940's, when, fortuitously, with Dr. E. Schwenk, they helped prove that arteries can and do synthesize cholesterol. The "why" of atherosclerosis has been his primary interest ever since.

Marx Brook is professor of physics at the New Mexico Institute of Mining and Technology. His research interests are in atmospheric physics, particularly cloud physics, lightning and weather radar.

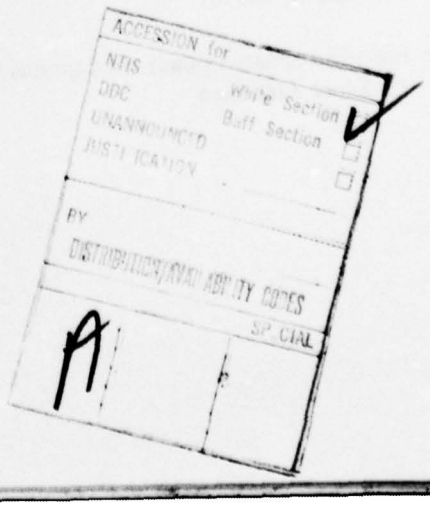
George Sandoz is a metallurgical engineer on the staff of ONR Chicago, serving a brief tour of duty at ONR Tokyo. His special interests are stress corrosion cracking, hydrogen embrittlement, corrosion fatigue, and fracture in steel and titanium alloys. He has also studied the notch ductibility and graphitization kinetics of cast irons and protective coatings for refractory metals.

Roy M. Johnson is professor of microbiology at Arizona State University. His primary interests are bacterial taxonomy and ecology and he is currently doing taxonomy on coal strip mine samples, cell walls of Antarctic bacteria, and some aspects of purple marine bacteria found at Kinko Bay, Kagoshima.

Harley J. Walker is professor in the Department of Geography and Anthropology at Lousiana State University. His interests lie in the areas of arctic hydrology, coastal morphology, and coastal defense systems.

C. Scott Littleton, currently Resident Director of the California Private Universities and Colleges Year-in-Japan Program in the International Division of Waseda University, is associate professor of anthropology at Occidental College, Los Angeles. He is a specialist in comparative mythology, especially Indo-European, and in the anthropology of religion.

THE COVER: A reproduction of kusae (popularly known as kirie) – a Modern Japanese art form using the "cut and paste" technique to create collages from handmade Japanese paper colored by natural plant dyes. Here we drew upon our own talent, for the artist is Eunice Mohri, Administrative Officer of ONR Tokyo.



CONTENTS

IVTH INTERNATIONAL SYMPOSIUM ON ATHEROSCLEROSIS, TOKYO, JAPAN

Nicholas T. Werthessen

On 22 August I took off on a trip that appeared a potentially pleasant one but which in fact produced symptoms of "jet lag" that lasted for over two weeks. Pan Am's new nonstop flight from New York to Tokyo required 13 hours, at the end of which one is 13 hours ahead of his normal rhythm. I have not previously seen a group of seasoned travelers so out of kilter at an international meeting. However, the session realized its potentials and was worth the discomfort.

At the last meeting in Berlin, the Japanese delegates competed with the Texans for the site of this one. Both had a strong case. The Texans spoke of the bicentennial, the Japanese of the fact that they were developing competence in the field and the session would prove beneficial to them. They were emphatic on the matter of adequacy of funds. The vote was close at the committee meeting. The writer, in fact, tipped the scales in favor of the Japanese and angered his Texas colleagues. Two years later the Texans were delighted when they recognized the shortage of funds that would have embarrassed them, and in Tokyo they thanked me for my prescience. As it turned out, our Japanese hosts outdid themselves, in spite of the fact that they too had to function in a declining economy.

This triennial meeting of those working on atherosclerosis is more a symposium than a session devoted to presentations of recent research. Such papers are presented, but lectures by chosen leaders in a field and workshops predominate and thus everyone is exposed to a high level of expertise. There were a number of plenary sessions, of which I have chosen four for this report as having primary relevance to naval medicine. The four happen to be the first four presented, which by their position set the tone of the session.

Dr. Colin Schwartz (Research Division, Cleveland Clinic, Cleveland, Ohio) gave the first lecture, which concerned the permeability of macromolecules into the arterial wall and the difference in permeability in various parts of the artery. Schwartz grossly delineates the different areas by the use of trypan blue (given intravenously) which penetrates very specific regions. These occur in the aorta at the orifice of the afferent arteries or at sites of injury, and are, in man and other species that develop the lesion spontaneously, the sites of predilection for atherosclerosis. The distribution is the same in animal models responding to dietary stress or specific agents.

The essence of Schwartz's conclusions is that macromolecules move with ease through the blood vessel wall. They do so the fastest in the blue-staining atherosclerosis-prone areas. As to the "why" of this, one can offer several explanations. One of these is based on the fact that in the "blue areas" there is a higher turnover rate of endothelial cells than in the areas that do not stain with trypan blue. Those who are devotees of the "filtration hypothesis" as to the basic cause of atherosclerosis see in this increased penetration rate of the large lipoprotein molecules support for their hypothesis. Those of us more mechanistically minded perceive the situation as one in which the underlying cells work harder and

need more nutrition to do their job; the high turnover rate of the endothelium is but another indication of the mechanical load on the system.

Fluid dynamicists hold that the site of the orifice is *the* one where there can be trouble from their point of view. Thus a physical science aids either view as to the difficulties that are pertinent to this phase of the system.

Schwartz's presentation set the stage for a lecture by Dr. J. C. F. Poole (Pathology Department, University of Oxford, England) on the endothelium, its integrity, and how that integrity is maintained. Poole described experiments in which the endothelium had been damaged, and discussed what happened afterwards and the need for endothelial integrity to maintain normal arterial function. He left the audience with the impression that reconstitution of the endothelium is a long-term process. This I find erroneous unless one adds the qualification that the rate of reconstitution is a function of the species with which one is working. It so happens that this is a long-standing point of argument between us. We are two of the co-authors of two papers on regeneration of the pseudointima in baboons. To a third co-author, the late Lord Howard Florey, and to me, it was extraordinarily rapid as compared to the rabbits on which Florey and Poole had based their earlier interpretations. To Poole the situation was in nowise the same.

Naturally I think I am right. Poole feels that he is. It is really a matter of small import except insofar as human therapy of arterial failure is concerned. If one takes Poole's viewpoint, the rabbit data indicate that surgical intervention will not be of great permanent value. Contrariwise, a recognition that primates behave differently from rabbits could encourage specialists in vascular surgery to use primates as models for various interventions not yet in current practice. One such would be the formation of "artificial arteries" by subcutaneous induction of a connective matrix surrounding an induced lumen. This approach would permit the surgeon to use an "artery" for a bypass instead of a vein as is commonly done today. A vascular surgeon and former ONR contractor in Boston tried this out in a baboon after working with poor results for years with dogs. He reported surprising success, and it is regretted that he did not publish.

Aside from the implication of species differences in endothelium regrowth, the combined thrust of the Schwartz and Poole lectures was important to further research on atherosclerosis. That thrust was the delineation of the role of the endothelium in maintaining arterial integrity. Schwartz showed that blood constituents can pass through it; but he also showed that such movement through the endothelium was a controlled process. Not all constituents of the plasma are permitted comparable rates of passage. Poole's delineation of the ability in all species for regeneration of arterial endothelium, thus permitting replacing injured, lost, or dying cells, pointed up what such loss meant in the progressing lesion. (Here, too, the audience of specialists did not need to be reminded of a current practice in animal experimentation, viz., the technique of "endothelium stripping" by passing an inflated balloon through the artery. An animal so prepared will develop more lesions per unit time in a dietary stress regimen than the untreated control.)

In summary then, one can say that it is now clear (a) that the endothelium, by regulating the rate of passage of plasma constituents to the subjacent smooth muscle cells, plays a significant role in the metabolism of the arterial wall; (b) that to maintain that role

the endothelium has a significant regeneration capacity continuously functioning to keep the arterial surface intact; and (c) when endothelial cells are lost, for any reason, the subjacent tissue is exposed to noxious influences to a far greater extent than was once assumed from the histology of the organ.

Dr. Wilbur Thomas (Department of Pathology, Albany Medical College, Albany, New York) gave the next lecture. In it he reviewed past concepts of the etiology of atherosclerosis and tried to fit them into an historical perspective. The Japanese could not have chosen a better person at this particular time. Dr. Thomas was trained as a pathologist. He is younger than I. When we first met as antagonists at meetings, he did not have my experience in the laboratory discovering that theories in biology have very short lifetimes. At one such session after we had presented data indicating that an artery had some control over what happened to it, Thomas presented his paper. His concluding comment was in effect, "These data prove the adequacey and accuracy of the filtration hypothesis in explaining atherosclerosis." He also glared meaningfully in our direction.

Some 20 years have passed since then. In fact, his group has contributed heavily to the concept that once a lesion has truly developed, the cells in that lesion have a different "modus vivendi" than the cells from which they were derived. Thus when Benditt came forward with the concept of a monoclonal origin of the atherosclerotic lesion, Thomas and his group were in an excellent position to study it. This they have done.

In his lecture Thomas summed up the current status of their studies. Using material from women with the appropriate isozyme genes on their X chromosomes they have, in the writer's opinion, come forward with a more appropriate analysis than provided by Benditt. Their concept is as follows:

(a) An area of the aorta is exposed to the appropriate insult.

(b) In responding to that insult the various cells increase their rate of mitosis.

(c) Along with that change of rate of mitosis, some of the cells, when dividing, produce daughters with a change in the hereditary code or a change in the overall interpretation of the code. (Sort of a late example of differentitation.)

(d) Within this population of altered cells there is also a wide difference in (1) competence to maintain the higher rate of cell division and (2) the number of divisions the cell line can undergo before cell division comes to its obligatory end.

(e) Thus, given an old enough lesion, it is to be expected that, within the limits of today's ability to discern isozymes, an old lesion would appear to be monoclonal in origin.

The writer must state here that as far as he is concerned this concept better explains Benditt's, Heptinstall's, and the Albany group's data than any currently at hand. He is also pleased to record that this time Dr. Thomas did not conclude his lecture with the forceful comment he made 20 years ago. Instead he showed the wisdom he had gained in the interim by a mild statement implying only that this is the way things appeared now, and it would be interesting to see where things stood three years from now.

The next speaker, Dr. Elspeth Smith (Department of Chemical Pathology, University of Aberdeen, Aberdeen, Scotland), is *the* current authority on the subject of "What is in a human atheroma in the form of lipids, proteins, et al." Until the "Little Lindau" conference held in Heidelberg three years ago after the Berlin meeting of this symposium, she had never, in any of her papers, stated publicly what she thought her data meant. On that occasion she startled the pathologists present by pointing out that her data could only be taken to mean that the "fatty streak" was the recovery phase of a response to an injury and that it was *not* the beginning of the atheromatous process. Instead she pointed to the "gelatinous lesion" as the real beginning of the process. After the meeting a group of American pathologists, who until that time had paid little attention to a few German pathologists who had defined the gelatinous form, banded together to study the point. The writer has not yet heard of any contradiction to Smith's conclusion.

In Tokyo Dr. Smith did it again. This time she took on the thesis that lipoproteins were the root of all evil in atherosclerosis. She now had at hand a sufficient number of aortae from patients who, when they died, had the following conditions:

(a) Normal lipoprotein levels and a normal blood pressure.

(b) Normal lipoproteins and hypertension.

(c) Hyperlipoproteinemia and hypertension.

From these patients she had obtained *normal* aortal tissue close by a chosen constant level of development of atherosclerotic lesions. In the following table she gave the actual concentrations in representatives of the three groups and stated that they were median values:

"LIPOPROTEIN-BOUND" CHOLESTEROL IN NORMAL INTIMA AND EARLY FIBROUS LESIONS

Subject Sex and Age	Serum Cholesterol mg/100 ml	Blood Pressure	Intimal Lipoprotein Cholesterol mg/100 mg Dry Tissue	
			Normal	Lesion
F.32y	130	$\frac{130}{80}$	1.3	3.2
M.61y	267	$\frac{130}{80}$	3.8	6.2
M.49y	332	$\frac{260}{130} - \frac{220}{120}$	6.4	12.5

Dr. Smith sagely permitted her audience to have time to read the table, then she drew attention to the fact that (a) the patient with both problems had *normal* tissue containing lipids at a concentration *equal* to that of the lesions patient with hyperlipidemia alone; (b) that the normal tissue of the patient with the two diseases contained *more* lipid than the lesion tissue of the patient who had neither problem; and finally (c) she pointed to the obvious extreme range of lipid concentration in normal tissue. Then she came forth with the only obvious conclusion. I believe I can quote her verbatim: "It follows that hyperlipoproteinemia can play, at most, but a secondary role in the etiology of atherosclerosis."

Thus, as Dr. Thomas pointed out earlier, as the data accumulate preconceptions have to be altered. However, in this instance, the nonexpert reader of this report who happens to have a high cholesterol or other lipid should *not* take comfort from Dr. Smith's findings. The relationship between the probability of a myocardial infarct and hyperlipidemia of any sort still stands. It has been known crudely since the Metropolitan Life Insurance Company made its study on the relationship of obesity and shortening of life expectancy in the beginning of the 20th century. The only thing that has changed is the manner of expression (now it is not pounds overweight but blood levels). Thin people still live longer, on the average, than fat people. They will continue to do so even if the level of lipids in an obese person's blood is not an *initiating* factor in the atheromata in their arteries. There are a number of reasons for this that are not germane to this report.

I was particularly fortunate on this visit to a country whose language was beyond my linguistic capabilities to have two colleagues who had no problems. The first of these was Dr. K. T. Lee, formerly a South Korean; the second, Dr. H. Imai, formerly a Japanese and at the time on sabbatical leave in Tokyo. Both these men are on the faculty of Albany Medical College and collaborate with us on the roles of the oxidation products of cholesterol as the source of the atherogenicity currently generally attributed to cholesterol.

Dr. Imai was working at the Tokyo Metropolitan Institute of Gerontology. Before his departure we had planned to give a paper at the session on the ability of 25-hydroxy cholesterol and the 3,5,6 trihydroxy to induce lesions in the pulmonary artery of rabbits when given intravenously in a saline suspension. During his stay in Tokyo these studies took an unexpected leap forward.

The prior work in Albany had been done on rabbits of the New Zealand White strain. Pathologists who had seen the preparations were duly impressed, but the two facts, (a) that the agents were infected intravenously in suspension and (b) that the response was observable *only* in the pulmonary arteries, caused a bit of eyebrow elevation. The anatomical rationale for the lifted eyebrows is as follows:

(1) The ear vein was the site of injection.

(2) From the ear via the jugular, the blood enters the right heart and is pushed through the lungs via the pulmonary artery.

(3) The lung is known as *the* filtering organ for the blood.

(4) Thus, one could expect the crystlas of the agents to be caught up by the lung and the *local* dosage to be far greater than the nominal 10 mg/kilo that had been administered.

(5) The "traditional" site of lesions–the rabbit's aorta when fed cholesterol–had to be examined in detail by electron microscopy to see any effect at the time the pulmonary arteries were seen narrowed on gross inspection.

In sum, to make this four-day finding palatable to others in the field who spent 10 to 16 weeks feeding rabbits large daily doses of cholesterol, there had to be evidence of aortal involvement.

Imai is a hard worker who gets a lot done. Thus, it did not take him long to use up the New Zealand White rabbits available in the laboratory. In order to keep on going, he did some preliminary studies with a strain known as Japanese White. In these the aortal damage was so pronounced, at the same time the pulmonary arteries showed the expected response, that there could be no doubt that a great deal of the agent had passed through the lung.

This sort of species' specificity and strain differences within species is a well known problem in modeling biological systems and in bioassay. In fact, some say it is a truism that the toughest stage of research on a problem is matching species and strain of animal to the problem one is tackling.

Imai then began an investigation of the various strains of rabbits available in Japan. He found one other of great potential value to atherosclerosis research. This strain develops hypercholesterolemia spontaneously and shows arterial lesions as well. To both Imai and me, this strain of rabbit (known to be a mutant from the parent stock) is the only strain that develops spontaneous atherosclerosis.

Thus, in a strong sense of the term, this strain of rabbit is similar to the White Carneau pigeon. It, too, was a mutation derived from a pigeon strain that did *not* develop atheroma. When the two strains were crossbred, geneticists were able to show that the tendency to develop lesions was based on several genes and modifiers of them.

The pigeon model, however, is not as good a replication of the human problem as is the rabbit. The two strains of pigeons showed identical levels of cholesterol and other lipids in their blood. In man, as indicated above, there are all sorts of blood lipid levels, and they do have an effect on the amount of fat in both the normal and lesion portions of the artery.

Last, but not least, the rabbit is a mammal. Its biochemistry is closer to the primate's type and it is a larger animal. Much more can be done with it to get to the final answer than with the pigeon.

At the moment our separate institutions are seeking special quarters for shipments of these strains. We cannot use the regular animal facilities for several reasons. Among these are disease and cost of maintenance. Institutional animal quarters are rigged more for boarding than breeding and, as such, must meet codes set up for animals used in experiments.

Our problem for the moment is much more that of a farmer: maximum production at minimal cost. As soon as we get it solved, we will import the breeding stock already promised to us.

As to our paper—with the new data on the Japanese White rabbits, we were able to answer all the objections before they were raised. Those present were impressed, and we are certain that the needed repetition of our studies will be done soon. The title of the paper was "Arterial Lesions by Oxidation Products of Cholesterol." The authors were Dr. Hideshige Imai, Albany Medical College, Albany, New York; Drs. Albert H. Soloway and V. Subramanyam, Northeastern University, Boston, Massachusetts; Dr. Nicholas T. Werthessen, Brown University, Providence, Rhode Island, and the Office of Naval Research, Boston, Massachusetts.

THE ANOMALOUS WINTER THUNDERSTORMS OF THE HOKURIKU COAST

Marx Brook

INTRODUCTION

In 1974, at the 5th International Conference on Atmospheric Electricity, T. Takeuti and M. Nakano of Nagoya University's Research Institute of Atmospherics reported studies of winter thunderstorms in which 9 out of 10 cloud-to-ground lightning flashes brought positive charge to earth. This report produced a host of comments from scientists at the conference who, in general, expressed a healthy skepticism regarding the polarity of the lightning strokes reported. In "normal" thunderstorms (summer-time occurrence in temperate latitudes), more than 90% of the cloud-to-ground discharges lower negative charge to earth. Positive currents to tall buildings and towers, such as the Empire State Building, have been observed and reported, but such discharges to open-terrain are exceedingly rare. This writer has made measurements of literally thousands of lightning strokes to ground and, with *no* exceptions, all strokes observed brought negative charge to earth. So it was with great interest as well as skepticism that we waited for additional reports from Takeuti and Nakano.

In 1975, Takeuti and Nakano reported measurements from summer thunderstorms in the vicinity of Fukui in which most strokes to ground were of the normal type. Thus, the winter thunderstorms of the Hokuriku Coast were definitely "upside-down" electrically! At their invitation and with NSF and ONR support, we joined with the Nagoya University investigators to study in finer detail, the electrical nature of the "anomalous" winter thunderstorms of the Hokuriku Coast.

THE HOKURIKU STORMS

The Hokuriku (meaning north land) area of the main island of Japan is a short stretch of coast line bordering the Japan Sea. The coast runs roughly in a SW to NE direction from Wakasa Bay to the tip of the Noto Peninsula. In the winter cold, dry air flowing SSW from Siberia picks up moisture as it passes over the Sea of Japan. A warm current from Kyushu flowing roughly parallel to the Hokuriku coast about 60-80 km from the shore line, provides a source of additional instability over which cumulus clouds form and intense convection sometimes ensues. The storms grow as they approach the land dropping about 300-400 mm of snow and rain during each of the months of December and January. Despite the heavy precipitation, the storm clouds seldom exceed 5 km (16,000 ft) in height.

The heavy snows (e.g., 45 cm overnight) are usually preceded by a small storm, i.e., electrically small, producing usually only one or two lightning flashes. The folklore is intersting on this point: the storm is called Ippatsurai, meaning single flash, and the cloud is called Yukiokoshi, or "snow caller". Obviously, this winter thunderstorm has long been recognized as the precursor of the very heavy snow falls for which the Hokuriku coast is so well known.

The storms are conveniently divided into two types. The Ippatsurai, or single flash storm appears to form via a monsoon type air flow, while the passing of a cold front will usually result in a storm which will produce from 10 to 30 flashes over a period of about two hours. Detailed statistical data can be found in Takeuti and Nakano (1976a and 1976b).*

THE 1976/77 WINTER RESEARCH PROGRAM

The 1976/77 program of research was a joint effort between the University of Hokkaido Department of Geophysics, under Dr. Choji Magono, the Nagoya University group under Dr. Toshio Takeuti, and the New Mexico Tech group headed by the writer. The Japan part of the cooperative program was headed by Dr. Magono, whose group made surface and balloon measurements of electric fields, electric charge on snow and rain, and the shape and population of snow crystals. The Nagoya and New Mexico groups carried out a unified program of multi-station electric field and field-change measurements for the study of lightning parameters and the overall electrical properties of winter clouds. In addition, a 5 cm wavelength radar was operated during the storms to provide storm location, velocity, precipitation intensity estimates, and the height of precipitation echoes. A radiosonde tracker was available for the balloon flights to receive the telemetered data which, in addition to the electrical parameters, also contained atmospheric pressure information.

In this report we shall concentrate on detailing the multistation electric field-change measurements along with some interpretations and implications of the results. Because this report was written two days before the end of the observational period, there has not been enough time to compare the balloon measurements with the surface multi-station measurements, nor to analyze all of the flashes recorded.

THE ELECTRIC FIELD-CHANGE MEASUREMENTS

A spherically shaped charge, Q, located at coordinates x,y,z where z is the height above ground, and x and y are the projected coordinates on the surface plane, will produce a vertical electric field E at a surface location (x_i, y_i) given by

$$E_i = k \cdot \frac{2Qz}{[(x-x_i)^2 + (y-y_i)^2 + z^2]^{3/2}} \text{, where}$$

k in MKS units is given by $K = 1/(4\pi\epsilon_0)$. The numerator 2Qz is the dipole moment of the charge Q and its image -Q in the surface, assuming the earth is a good conductor in the electrostatic sense.

* An overall very readable account of these winter storms has been given by E. T. Pierce, 1976, *Winter Thunderstorms in Japan – A Hazard to Aviation,* Naval Research Reviews, Vol. XXIX. No. 6, p. 12.

When a lightning flash to ground occurs, we assume that some fraction (or all) of the charge is effectively neutralized, and, by superposition, we may write our equation in the same form, i.e., a change in electric field ΔE_i produced by a change in charge,, ΔQ, will be measured at the $i^{\underline{th}}$ station as

$$\Delta E_i = k \cdot \frac{2(\Delta Q)z}{[(x-x_i)^2 + (y-y_i)^2 + z^2]^{3/2}}$$

For a ground stroke, the charge ΔQ may be thought of as "effectively lowered" to earth (or a charge of opposite polarity, $-\Delta Q$, raised to the cloud).

The above discussion, though brief, illustrates how we may utilize the measurements of field changes, ΔE_i, at a number of stations to infer polarity, magnitude, and locations of charges brought to earth by lightning flashes. For example, since a single charge and its location in space is describable by the four variables x,y,z,Q, it is in prinicpal possible to determine its magnitude and position by independent measurements of ΔE made at four stations simultaneously.

INSTRUMENTATION

a. Sensors. The basic instrument used in the lightning field-change measurements is high-impedance, electrometer type amplifier known as a "slow" antenna. It consists of a flat plate antenna approximately 35 cm in diameter which is connected to a charge amplifier. The antenna and circuit are shown schematically in Fig. 1. A change in electric field ΔE, produces a change in the induced charge, ΔQ, on the flat plate. Thus, $\Delta E = -\frac{\Delta Q}{\epsilon o\, A_{eff}}$, where ϵo is the permittivity of free space, and A_{eff} is the effective area of the plate. Since the change in output voltage ΔV_o, of the charge amplifier is given by $\Delta v_o = \frac{\Delta Q}{C}$, we get $\Delta V_o = \frac{\Delta E \epsilon_o\, A_{eff}}{C}$.

A "fast" antenna is essentially the same instrument, but with a time constant of about 100 microseconds instead of 10 seconds. The fast antenna is used to emphasize the rapid changes in electric field such as are produced by lightning discharges, as compared to the slow antenna which responds faithfully to the slow as well as the fast changes, but which, as a consequence, must be operated at lower sensitivity to keep them within the dynamic range of the amplifier.

Also operated in this study were electric field meters located at three of the four field-change stations, and a video camera – tape recorder system of 120° azimuthal coverage.

b. Recorders. As discussed earlier, the Ippatsurai storms produce as few as one lightning flash per storm. It is therefore important to record *every* event, and to accomplish this we used the auto-reverse tape recorder. This recorder, using special tape, will run continuously for as long as 5 days, after which time the tape must be replaced. The tape is run at 3¾"/sec and will provide a reel-to-reel record for approximately 2 hours in each direction. After the occurrence of a lightning event which is noted at the main station in Unoke, there is approximately 4 hours of recording time at each station before the event is erased. Despite the heavy snows it was usually possible to change the tapes within this four hour period.

STATION LOCATIONS

Data were obtained from a slow and fast antenna located in the Nagoya University's instrumentation bus at Unoke, about 15 km NNE of Kanazawa. A high and a low gain channel for each instrument required the use of two auto-reverse stereo recorders. Two other stations, one to the southeast about 4 km distant, and another to the southwest about 6 km distant, were outfitted with a slow antenna and a single high and low gain channel auto-reverse recorder. The fourth station in the network was located approximately 9 km southwest of Unoke, near the city of Kanazawa. Here too, we recorded a high and low gain slow antenna channel.

RESULTS

We can indeed assert, with Takeuti and Nakano, that the Hokuriku storms are very different from the usual summer thunderstorms, not only in the polarity of the charges brought to earth, but in other features evident in the fine structure of the electric field-changes:

a. The charge lowered to earth by ground strokes is positive in the seven out of eight flashes analysed to date.

b. In storm A of 12/17/76, three ground flashes were identified, and in each case, the return strokes not only lowered positive charge, but were followed by a long-continuing current. The magnitude of the return stroke field-changes was less than about 5% of the field-change produced by the continuing currents which followed.

c. In storm B of 12/18/76, three out of four return strokes identified lowered positive charge to earth. One of these was a single stroke flash; the other two each consisted of two return strokes, revealing that the "anomalous" lightning also occurs in multiple stroke flashes.

d. The time interval between the individual strokes of a multiple stroke flash is more than twice as long as is found in "normal" storms.

e. By comparing the sign and magnitude of leader field-changes from each of the four stations, it appears probable that the lightning charge is often located in-cloud at a height considerably *lower* than in "normal" storms.

f. In qualitative agreement with *e* above, it appears that the maximum surface electric fields beneath the winter storms is higher in value than in summer thunderstorms. Values of electric field as high as 20,000 V/m were a common occurrence for prolonged periods.

g. Although the number of lightning flashes per storm is small, the high electric fields at the surface persist for a considerable period both before and after the flash. From this observation we infer the existence of high electric fields within the clouds *without* the occurrence of detectable discharges.

DISCUSSION

The multiple-station measurements have revealed many intersting and new aspects of the electrical nature of these winter storms. A significant feature to be noted is that the O° C or freezing level in these winter storms is not much above the surface, perhaps only 200 - 500 m in height. This implies that the cloud is essentially all at a temperature below freezing. The electrical evidence for a low lying charge then implies that the electric charge is located at a temperature of about -10° C. If this is true, then we have one point of agreement with normal clouds: the charges appear to be located at about the same temperature level. Remembering, however, that in one case the charge is positive and in the other negative, we are about to embark on a new dilemma!

Some charge separation theories which rely upon precipitation to provide gravitational sedimentation have required the heavier particles to carry the negative charge downward. The problem is obviously now more difficult. It is perhaps wholly premature to speculate on the nature of possible charge separation mechanisms in these clouds, but we have mentioned them to indicate a partial source of keen interest in these newly "discovered" storms.

It is now somewhat clearer as to why these storms pose such an extreme hazard to aircraft. Although some small clicks and pops of static can be heard on the surface during the approach of a storm, there is hardly any visible or severe radio noise warning of the existence of strong fields within the clouds, as pointed out earlier by Pierce (1976). But a heretofore unsuspected additional hazard appears to be present. This danger involves not only the triggering of a lightning flash due to cloud penetration by aircraft, but an increased probability of triggering a stroke of the long-continuing current variety. Long-continuing currents (Brook et al., 1962) generally involve much larger values of charge than do ordinary return strokes and have been shown to be, because of the large charge involved, the type of stroke which is primarily responsible for starting forest fires. The large fraction of strokes to ground of the continuing current variety, and the long duration between the multiple strokes in a flash in these winter storms both point to an increased hazard in the event of a triggered stroke.

We have only begun to explore the details of these anomalous winter storms. Unfortunately, the wind velocities and the wind shear is so large that ordinary weather radar scanning rates are much too slow to explore the cloud structure in detail. Winds observed at cloud height often exceed 60 knots. Rather than trying to scan a hemisphere of sky, it is perhaps better to fix the vertical plane scanned by the radar to one perpendicular to the cloud motion, allowing the clouds to move through the plane much as is done with vertically pointing radars. The need to observe these clouds at close range as well as overhead really requires the use of a fast scanning radar such as described by Brook and Krehbiel (1975). Such a radar is unfortunately not presently available in Japan.

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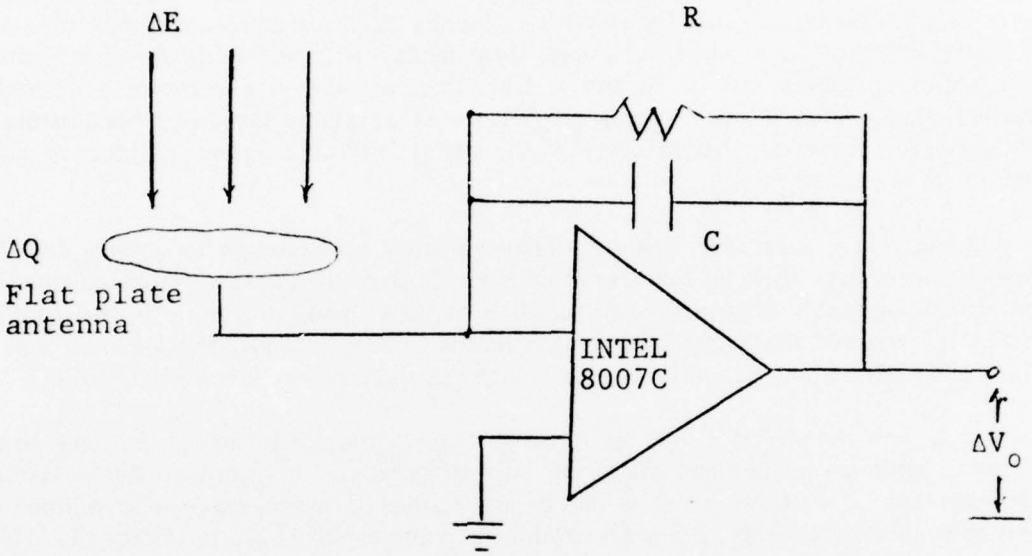

Figure 1. Basic Slow Antenna Circuit. The product R · C is the time constant and is fixed at 10 seconds. The sensitivity is controlled by the choice of capacitor. Input impedance is 10^{12} ohms.

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THE RESEARCH INSTITUTE OF POLYMERS AND TEXTILES, YOKOHAMA

E. A. Kearsley

The Ministry of International Trade and Industry (MITI) is an agency of the Japanese Government which, along with many other activities, maintains about 15 laboratories distributed about Japan. One of these laboratories, the Research Institute for Polymers and Textiles (RIPT), is very heavily involved in basic and applied polymer research. RIPT traces its origins back to the Silk Laboratory established in 1918, thence through the Textile Research Institute to its present organization in 1969. The emphasis in 1969 was shifted to synthetic polymers and it has since been broadened to include also biopolymers, systems engineering and environmental and energy problems of the polymer and textile industry.

RIPT is less than an hour out of Tokyo and an easy walk from the Yokohama central railroad station. Its physical plant consists of several buildings on a small compound in the middle of the city, but in the near future it is scheduled to move to new quarters at Tsukuba Science City, along with many other national laboratories.

The director of RIPT is Dr. Mitsuo Suzuki and the Chief Research Planner is Dr. Masakai Hasegawa. The staff of the organization consists of 135 people of whom 103 are engaged in research (as opposed to administration); about 2/3 of these are Ph.D. level. The total operating budget is just under one billion yen (a little more than 3 million dollars) of which over half goes to personnel expenses. Of the research expenses, basic research at 28% is a substantial item while various special projects and applied problems consume the rest.

Hachiro Nakanishi showed me the work he is doing with Dr. Hasegawa, the Chief Research Planner, on photo polymerization of single crystals. They have identified some forty diolefin compounds which polymerize by formation of a cyclobutane ring between olefins when single crystals are exposed to light. The most active of these, 2,5-distyrylpyrazine (DSP), will achieve molecular weights in this way, up to 300,000 in the right circumstances. Mr. Nakanishi showed me a moving picture (in real time) of a DSP crystal exposed to light from a xenon lamp as seen through a polarizing microscope. Striations appeared in a matter of seconds and a series of parallel cracks developed, increasing in number until the crystal looked like whalebone or perhaps an overused toothbrush. The cracks are aligned along the polymer chain axis in the crystal. To establish the mechanism of the phenomenon, studies of the kinetics were made. It was found that by selecting the wave length of the irradiation, the reaction can be done in two steps, oligimerization followed by polymerization. A rigid crystal lattice at a temperature far below the melting point was necessary in order for the polymerization to proceed smoothly. It is inferred from this that the polymerization is controlled by the detailed geometry of the monomer lattice. Crystallographic studies of the details of the structures showed that the separation between double bonds of adjacent monomer molecules (3.94 Å compared to the cyclobutane bond length of about 1.55Å) makes it less favorable for a bond to form there than for a bond between monomer and dimer. In a graphic demonstration, I was shown diagrams of the projection of

monomer and polymer crystal structures almost exactly superposed in a plane perpendicular to the chain growth axis, demonstrating that little if any motion of the center of gravity of monomer molecules is required in the polymerization. Of course, two dimensional projections only give part of the story for this inherently three dimensional process but, as one would expect, most of the symmetry of the monomer crystal is inherited by the polymer crystal. The term "four-center type crystalline state photopolymerization" is used by this laboratory and, more generally, the term "topo-chemical" reaction.

But what was most surprising to me was Nakanishi's demonstration that this whole polymerization process is, in a sense, reversible. As I understand it, starting with a DSP monomer crystal and irradiating it with progressively higher frequency light, a progressively higher molecular weight crystal is formed. On the other hand, if a high molecular weight polymer crystal is heated slowly up to 300°C, the molecular weight decreases until a monomeric crystal is recovered. The inference is that thermal depolymerization is a polymer-lattice controlled back-reaction of the monomer-lattice controlled photo-polymerization. For instance, data were shown me on two polymer crystals of chain lengths, 1670 Å and 265 Å respectively, heated and held at 290°C. The higher molecular weight crystal quickly broke down to a length of 370 Å and then remained stable; on the other hand, the low molecular weight crystal did not change. The existence of a maximum molecular length for a given temperature has also been demonstrated for solutions of this material. It is related to the rigid rod-shaped molecules rather than to any crystal lattice effects.

I was told that there is much interest in these solid state reactions because one can hope to achieve high yields, high selectivity and very regularly structured molecules – even optically active molecules might be producible from a chiral crystal. Mr. Nakanishi plans to look at the preparation and crystallography for other solid state reactions.

Dr. Masao Kato of the Organic Chemistry Laboratory was doing some related research synthesizing organics. His most successful project was the development of a new photoresist polymer, poly (vinyl ethyl cinnamate) or PVEC made by cationic polymerization. This material is claimed to be a much better one to use as a photoresist in the manufacture of IC's and LSI's than the currently used poly (vinyl cinnamate) or azide-rubber since it has better photo sensitivity, resolution and mechanical properties than PVC and better chemical stability and inertness to oxygen than AR (which must be irradiated in oxygen free atmosphere). In effect, the new material achieves the good features of each of the current photoresists without the bad features.

All these materials are usually used with added materials, called sensitizers, to extend the range of wavelengths of active light. To eliminate the need for sensitizer, Kato has developed another new polymer derived from poly (benzyl methacrylate) by substitution of up to 30% phenylmaleinide groups. This material showed good sensitivity for a broad range of the visible spectrum (up to wave lengths of over 400 nanometers, whereas unsensitized PVC is sensitive only up to about 300 nanometers). Kato tells me that he is still unsatisfied by the dark reaction rate (the reaction rate when not illuminated). I have no doubt he will soon find a way to improve it, but the material as it stands is already under consideration for commercial production. In another somewhat different direction, Kato is also synthesizing

selenium-containing polymers to be used as reagent. These will replace low molecular weight selenium compounds and will eliminate some serious problems of toxicity and odor.

In the Biofunctional Materials Laboratory, Dr. M. Hata, who works with Dr. Keishiro Tsuda, showed me his collection of slime molds cultured in the dark at 20°C on wet, oatmeal-coated paper. The attraction of slime molds is that they very quickly grow toward or away from extremely low concentrations of certain chemicals, a behavior called chemotaxis. For instance, slime molds are pro-glucose but anti-hydrochloric acid. Hata and Tsuda are investigating the role of cell membranes in the process by which the slime molds recognize chemicals. Dr. Hata showed me data they had taken with several salts demonstrating that, for each salt, there is a characteristic concentration below which the slime mold cell membrane potential is independent of concentration and above which the potential is roughly proportional to the logarithm of concentration. These characteristic concentrations also correlate with the chemotactic behavior of the slime molds. By electrophoresis of droplets (100 micron diameter) of slime molds, it was shown that the surface potential of the membrane is proportional to the zeta potential. Hata and Tsuda conclude that changes in membrane potential are essentially a phenomenon relating to conditions at the cell surface.

Kenji Fukuta of the Materials Engineering Laboratory is studying fiber-reinforced plastics (FRP). He has developed molding methods which combine good mixing of the fibers and resin with the control over the orientation of the fibers. He has studied the effect on the mechanical properties of polyethylene-glass FRP of the number of filaments in the strands of chopped glass fibers. The effects on flexural behavior are reasonably well explained by a modified composite-beam model. With low pressure molding using a new method, continuously molded FRP board with large flexural strength and modulus is produced. He showed me some carbon-epoxy composites and some polyethylene-glass and polyester-glass sheets, which were also made with his new process. They were clearer and showed less of their fibrous structure than conventionally formed FRP, as well as having increased strength. Fukuta is also working on the the use of three dimensionally woven reinforcing structures for FRP such as those originally developed for the construction of rockets, nose cones and radar domes. He showed me a handsome and structurally strong beam of such a reinforced plastic (with beautiful grained wood veneer) designed to eliminate thermal cracking. Pipes, tubes and channels were also formed with woven reinforcing structures. Other work was aimed at improving urethane-glass insulation for use at liquid helium temperatures. I also saw a syntactic foam otter board for Japan's vital fishing industry as well as a high speed apparatus capable of spinning natural fibers at a rate of 200 meters per minute.

Dr. Tadao Kataoka of the Physical Chemistry Laboratory is the house rheologist. He works with disperse systems, frequently glass beads or glass bubbles in polymer melts. He studies mixing, yield stress, normal stresses and the correlation of mechnical properties with filler content. He has developed a very successful empirical law for predicting viscosity of a suspension from the glass-bead filler content. Kataoka also studies transient phenomena (stress growth, stress relaxation, etc.) with a cone and plate rheogoniometer and convergent and divergent flows and other non-viscometric flows with equipment of his own design. In a device for studying elongational viscosity, the forces are measured on a jet extruding a filament simultaneously being wound up on a rotating drum. Dr. Kataoka also showed me an extruder working on the principle of a Weissenberg pump, that is, the extrusion pressure is generated by the normal forces of shearing between a fixed and a rotating plate. I have seen

other extruders of this type, Bryce Maxwell at Princeton has developed one for instance, but the particular virtue in this case is that the device can be used simultaneously to mix filler or fibers with the resin and to extrude. As an example, I was shown some polyethylene loaded with carbon fibers which had been mixed and extruded by this machine. In this particualr case, the high rate of shearing had reduced the 3mm fibers at input to 0.5 mm fibers in the extrudate. How much effect this had on the mechanical properties was not shown, since data on the mechanical properties of this material had not yet been taken.

It is a current dream of polymer scientists to find a way to produce super-strong polymers by inducing an almost perfect degree of molecular alignment. If this were achieved one would expect that deformation of the material would proceed by altering stiff bond angles or separating chemical bonds rather than by free rotation of bonds and unfolding of flexible chains, as is thought to be the ultimate source of deformation for common plastics. Recently, considerable progress has been made toward achieving this dream by both chemical and physical means. Rigid polymer chains which naturally tend to crystallize in this way have been synthesized. Polymer whisker-crystals have been observed which have properties very similar to metal whiskers and show a high degree of alignment of the polymer molecules. High-pressure extrusion has produced polyethylene fibers at least two and a half times stronger than soft-steel wire. Roger Porter of the University of Massachusetts once suggested to me that there is the potential for increasing this by another factor of five or more if all the molecules could somehow be perfectly lined up and properly packed. Not surprisingly, at RIPT there is interest in these ideas also and several active programs relating to these problems have been going on.

Dr. Hisaaki Kanetsuna of the Polymer Physics Laboratory is well known for his extensive studies of the crystallization of polymers and his work on high pressure extrusion of polymers. He and his colleagues have been interested in EEC (extended-chain crystals as opposed to the more usual folded-chain crystals). Kanetsuna and colleagues have made an extremely thorough study of the crystallization of polyethylene at high pressures. They find that above a pressure of about 2 or 3 thousand kilograms per square centimeter, there is a narrow temperature range in which EEC are formed and at higher pressures, this temperature range increases. On the other hand, annealing of folded chain crystals at high pressures (5300 kg/cm^2) produced thickening of the lamellae but little or no ECC. An extensive and continuing study of the crystallization processes in polyethylene at high pressures has been conducted over the last few years using dilatometry, fractionated samples to study molecular weight effects, GPC, DSC, and electron microscopy.

Dr. Kanetsuna's laboratory is also engaged in a detailed study of high-pressure extrusion of polymers. They have examined a variety of polymers including polyoxymethylene, polypropylene and fluorocarbons, but the most exhaustive studies have been those on high density polyethylene. A commercial grade with viscosity-average molecular weight of about 8.5×10^4 and a melt index of 0.25 is used. Two extrusion systems are available for these studies, a hydrostatic arrangement in which the extrudate emerges at atmospheric pressure (capable of reservoir pressures up to six kilobars) and a fluid-to-fluid extruder in which the material is deformed between two pressurized reservoirs (high pressure up to ten kilobars, low pressure up to five kilobars). Both extruders can be operated at temperatures up to 200°C.

In an early study, the critical effects of the cone-angle of the extrusion die were elucidated. When large cone-angles were used, irregular extrusion was observed ranging from badly cracked extrudate to slight periodic fluctuations in diameter along the length of the extruded cylinder. This was presumably a result of so-called "stick-slip" or "melt-fracture" behavior, much studied by commercial research laboratories. With low cone-angles a remarkable, highly oriented extrudate with a very smooth surface resulted. Studies were made with extrusion ratio ranging from 30 to 9 – the extrusion ratio is defined as the ratio of cross-sectional area of the material before and after extrusion. At high extrusion ratios (above about 6) the extruded material was almost glass clear rather than the paraffin white of normal polyethylene. It had a very high modulus in the axial direction and a surprising fibrous nature. Roger Porter and his colleagues at the University of Massachusetts also have a research program on this unusual material and it is at his suggestion that I visited RIPT. Dr. Kanetsuna and Kazuo Nakayama are engaged in a detailed study of the morphology of these materials. They have used wide-angle and small-angle X-ray diffraction, density measurements, thermal contraction, and birefringence measurements to establish the processes of molecular orientation and the deformation of the original lamellae. They conclude that the transparency and anisotropy of the extruded polyethylene can be accounted for through the typical fiber structures and that, particularly for extrudate from high extrusion ratios, the material consists of highly oriented crystallites mixed with interfibrillar amorphous (but oriented) material in bundles. A concommitant result is that the Vickers hardness number increases and the thermal shrinkage decreases with extrusion ratio at high extrusion ratios (greater than about 6). Kanetsuna points out that, by conventional reasoning, the higher the orientation of amorphous material, the greater the thermal shrinkage. That the reverse occurs in this case, he attributes to the fact that the fibrillar structure is loaded with a large fraction of highly oriented crystallites which inhibit the recovery of the fiber. The Vickers hardness test produced data very sensitive to the extrusion conditions but the anisotropy of the material and the small diameter of the extrudate (on the order of 2mm) made the measurement difficult. Plans are to examine extrudates of larger diameter in more detail in the future.

There was much work at RIPT that I had no chance to investigate in my short visit. Considerable work on biopolymers is under way, for instance: synthesis of peptides and proteins, radioisotope studies of biopolymer activity, studies of the structure of water near polar membranes, tests of medical implant materials and studies of biomechanisms and systems, particularly biomembranes and simulated membranes. In organic chemistry there is work on permanently stabilized polymers, steriospecific polymerization, living polymerization and block copolymers, and radiation chemistry. There is active work on characterization of polymers, NMR, GPC, DSC and work on developing degradable plastics, the use of polymers as sensitive metal ion indicators and the testing and standardization of polymers particularly with respect to flammability and durability. Dyeing of textiles is also of interest and an ingenious device for color measurement utilizing an acousto-optical filter was mentioned to me. A systems engineering group applies modelling and computers to the problems of the polymer and textile industries.

The Bulletin of the Research Institute for Polymers and Textiles is published quarterly. Unfortunately, it is in Japanese, but a synopsis is given in English for each article and captions of figures and tables are also in English. With these aids an English reading specialist

can pretty much get the drift of an article in his own field. Number 110, the second issue of 1976, is almost entirely devoted to the work of Kanetsuna's laboratory on pressure crystallization and on high-pressure extrusion.

TSUKUBA, A NEW TOWN, A NEW UNIVERSITY

E. A. Kearsley

Some 60 kilometers northeast of the fleshpots of Tokyo's Ginza, in the shadow of a small moutain, lies a diamond-shaped plain which, at some time in the geological past, was overlaid with several feet of gummy clay. It is this coating of clay which made the plain of only marginal agricultural value so that it remained, even in land-starved Japan, pretty much a wilderness with only a few villages and little farming. When, in the early 1960's, a commission was charged with seeking means to disperse population and activities from an overcrowded and growing metropolitan Tokyo, Tsukuba was available, a natural site for locating a proposed new town dedicated to science, research and education. It was to be a model of new town planning, a government city designated for national research laboratories and for a new university. By act of the Japanese Diet, the plan was approved and construction began in 1972. From the start, this was no half-measure. The projected cost of the project was equivalent to some three billion dollars and a community numbering some 200,000 was envisioned, including scientists, teachers, students and an array of support personnel along with the necessary houses, businesses, cultural and entertainment centers to serve the community.

The official name of this new complex is rendered in English as Tsukuba New Town for Research and Education or, sometimes, as Tsukuba Academic City but in common parlance Tsukuba will do. The name is an ancient one attached to the nearby mountain. Tsukuba has been assigned an area of 2,700 hectares, somewhat less than 7,000 acres, and it will eventually house 43 research and education institutions. The core institution is the new University of Tsukuba, now about half built and already in operation. It occupies 245 hectares (about 600 acres) of the new town. By Japanese standards such a campus verges on the prodigal. The buildings and landscaping reveal the imaginative architecture and careful planning that have been lavished on the design. By all odds it is the largest and plushest university campus in Japan.

The physical plant, however, is by no means the most unusual feature of the university. For one thing, there are no conventional academic departments in the university. Instead there are academic "clusters" into which the university is physically divided, in some ways like the arrangements at Santa Cruz or La Jolla in California. Cluster one houses the College of Humanities, the College of Physical Sciences and the College of Social Sciences. Cluster two contains the College of Agriculture and Forestry, the College of Biological Sciences, the College of Comparative Culture and the College of Human Sciences. Cluster three will consist of the Colleges of Basic Technology, Informational Sciences and Social Engineering (the latter college will deal with such disciplines as city planning and economics and not what the more paranoid reader may have inferred from the name). The School of Fine Arts, School of Medicine and School of Physical Education each constitutes a cluster in itself. Core libraries service each cluster, presumably each stocked and staffed to meet the needs of specialized subject matter particular to the cluster. However, there is no ordained faculty for each cluster – instead there are 26 Research Institutes with specialities ranging from Agricultural Engineering to Structural Technology. These research institutes supply the teaching staff for the colleges as the need arises. In my notes on the visit, I remark that the professors

sometimes lapsed into the term "department" despite an obvious effort to use the new terminology, but perhaps this was only a translation problem.

The whole idea is flexibility. The small clusters are intended to respond to student needs with less inertia than could a conventional, large university. On the other hand, the separation of research function from instruction function is aimed at avoiding compartmentalization and at allowing a flexible response to multiple social needs. ("Social needs" is a term much used in the planning documents for Tsukuba University.) The research institutes are conceived as project-oriented and are set up to encourage and provide opportunitites and facilities for interdisciplinary research. For instance, it is possible for a professor to have joint appointments at more than one Research Institute where his particular talents and expertise are needed and at the same time to teach courses at several different clusters. Furthermore, the Graduate School is also a separate entity with its own initiative and programs. A number of two-year Master's Degree Programs are offered, including Applied Science, Medical Science and Integrated Technology, but many more five-year Doctor's Degree Programs covering all the traditional disciplines are available. One strangely named doctoral program (and a Research Institute) is dedicated to "Defectology" which is not a branch of solid-state physics or crystallography but the official translation of a Japanese term for the study of psychology, sociology and social therapy of the physically and mentally handicapped.

The design of the administration of Tsukuba University is also most innovative by Japanese standards. As opposed to the usual system of government by faculty meetings and a university Senate with veto power, in the new scheme, there is a Senate composed of a senator from each college and from each research institute and, instead of a single president's office, there are five chancellors who serve in the areas of academic affairs, research, student affairs, medical services and general affairs, respectively. Each chancellor has considerable power and, in principle, this system removes vital decisions from the slow grinding of traditional faculty meeting mills. One professor pointed out to me however that, in practice, most important decisions hinge ultimately on the whims of the Ministers of Education and of Finance which cast deciding votes by controlling the distribution of money. To judge by surface appearances, they have been quite generous to date.

Japan as a nation decided some years ago to enter the international market for computers and computer systems. Government subsidies have been granted Japanese companies to develop competitive computers. An Inter-University Computer Center was started in 1964 at the University of Tokyo; it was later expanded to six centers at each of the "imperial" universities and ultimately, all other government universities were linked to these centers through private lines. Last year, an experimental line was installed between Tokyo and Kyoto computer centers (with a transmission rate of 48,000 bps) as a step in forming a nationwide integrated system. For private universities the Ministry of Education, Science and Culture subsidizes two thirds of the purchase price of computers. Not surprisingly, at Tsukuba, the newest and most innovative of the national universities, computers have been emphasized from the planning stage. The "Tsukuba Integrated Campus Information Processing and Storing System" (TICIPS) is a system built around a central, large-scale computer and front-end processors for data and preprocessing. It is organized to integrate all university computer uses into an on-line system, with the ultimate aim that anyone can use the computer at any time and from any place on campus. At present, eight remote job-entry terminals, forty-nine cathode ray tube terminals and ten teletype terminals are scattered about the campus. To handle the traffic, the central processing unit, input-output multiplexor and front-end processor are each

dual. Specially designed channel finders interface the communication lines with the front-end processors. On command, they locate a vacant channel, connect up with the front-end processor and, after log-in, they automatically disconnect 10 minutes after a request for input if there is no answer. TICIPS was developed by four professors and the professional staff of Tsukuba and it is, of course, constantly being improved. To make these facilities accessible to the students, one of the two courses required of each entering freshman, regardless of his field of study, is "Introduction to Information Sciences." (The other and, undoubtedly, more difficult required course is Japanese Composition.) The course is one term long and consists of a lecture, an exercise and a laboratory session each week. A special installation, consisting of three minicomputers with common files and time-sharing system and 21 terminals all tied into TICIPS, is used. Marked-card inputs are used to avoid the need for card punch training which was found to take a good deal of time for non-typewriting students. The terminals are fitted with audio output, cathode ray tube, interacting pencil, teletype and facilities for handling oral language, diagrams, maps and Chinese characters or other writing and typing. The day I visited the Cyrillic alphabet was set up on the teletype. The problem of handling the kanji and kana (the Chinese characters and Japanese syllabaries) of written Japanese has inhibited the use of computer-aided instruction in Japan. By using character pattern generators and random access slide projector inputs and audio inputs, such difficulties are being overcome at Tsukuba. Teaching of medical students figures particularly prominently in the immediate plans. Diagnosis of heart conditions by using a heart beat simulator to generate the individual noises of normal heart valve operation one at a time will be taught. After these are mastered, the computer will synthesize them into the sound of normal heart beats and then compare them to the sound of abnormal heart beats. Similar training in reading X-ray films uses random access pictures, the pointing pen and explanations through the keyboard.

Research and development continues on this computer system: a large data base and information retrieval system is being developed with the cooperation of Toshiba Corporation; administration, library and hospital system are in design; input, edit and hard copy output systems capable of handling kanji, kana, alphanumerics, etc., in random combinations are well on the way; a Japanese language data base containing information on the Science Research Fund contracts and contractees (Japan's NSF) is in process. Ultimately, the successful computer innovations at Tsukuba are to be extended to other universities.

A recurrent theme at Tsukuba is that of international and interuniversity cooperation and exchange. Much attention is indeed given to language and area training. Furthermore, correspondence has been initiated by universities in twelve different countries on the possibilities of cooperation, student and faculty exchange and the like. Many of these feelers come from Southeast Asia (from the United States, some 15 universities were mentioned). All of these initiatives have been from abroad because the Ministry has done little, so far, to finance overseas cooperative programs. Still, the insularity of the Japanese university system is certainly not a neglected topic in Japan and some attempt to improve the situation can certainly be expected at this newest and most responsive university.

Some years ago, Chancellor Fukuda wrote an article stressing that the new university seeks to eliminate the stagnation which imposes itself upon some institutions. He mentioned that, among other things, it is designed to stimulate healthy competition and to establish a sound and viable relationship with society by being responsive to the needs of the times and

of the future. No one doubts that the administration and standards of Tsukuba are designed partly to eliminate the potential for future student-inspired strife such as swept Japan so bitterly in the late 1960's. In a *Physics Today* article of February 1975, Tsukuba was compared to Akademgorodok, the science city at Novosbirsk. If Tsukuba is Japan's answer to the Russian science city, there are certainly substantial differences. Tsukuba will be definitely larger and certainly more controversial. My experience is that there is a reluctance on the part of many Japanese professors to accept the changes with tolerance, not to say approval. Many students are reluctant to leave the sushi parlors and pachinko halls of the large urban areas, so that Tsukuba is not flooded with applications as are the traditional "imperial" universities. Many of the professors, too, continue to live in Tokyo and commute great distances to the university. The Japanese are inheritors of an ancient and unique culture and they are in some ways very conservative. Tsukuba University is at this time about half built and half populated, having been somewhat slowed down in its progress by the "oil shock." It is apparent that, in spite of its great progress to date, it must still prove itself.

THE NATIONAL RESEARCH INSTITUTE FOR METALS

George Sandoz

The National Research Institute for Metals (NRIM) is essentially an in-house laboratory for the Science and Technology Agency of Japan, which provides 90 percent of the support (approximately $10 million per year). The remaining sponsorship comes from other governmental agencies such as the Ministry of International Trade and Industry and the Agency for Environmental Protection. A few tasks are handled under contract for industries, but this is done indirectly through various governmental agencies.

NRIM was established in 1956 and is organized into five groups, each containing three divisions. The primary functions of these groups are as follows:

1. Materials Group (1) – metal physics involving both ferrous and non-ferrous metals.

2. Materials Group (2) – responds to national projects, and involves electronics materials, nuclear materials and high strength materials. Project areas involve breeder and hot-water reactors, fusion nuclear fuels, space deep-sea diving, high speed transportation, MHD.

3. Process Metallurgy Group – metallurgical chemistry and process metallurgy and development. Projects involve improving extraction and refining processes. As an example, work is underway on the continuous electrolitic refining of Cu, Zn and Ni.

4. Metal Processing Group – welding, foundry practice, powder metallurgy and one division concerned with corrosion control.

5. Strength Group – a host of activities including NDT, composite materials, the basic approaches to increasing metal strength. Fatigue and creep properties are included.

Materials Group (2) is scheduled to move to Tsukuba New Town for Research and Education by about 1979. Earlier construction at the new site provided a building for testing superconducting materials (1975) and a laboratory for testing materials at high temperatures in special atmospheres (1976).

This visit began with a description of the organizational features and research philosophy of NRIM by the Director, Dr. Toru Araki. Following this there were tours of the Fatigue Testing Division and Creep Testing Division (Strength Group) and the Welding Division (Metal Processing Group). Discussions were also held with various members of the High Strength Materials Division (Materials Group (2)) and the Ferrous Materials Division (Materials Group (1)). For about an hour and a half a group was convened to hear the writer describe materials activities at ONR and NRL. The visit was frustrating in one sense; too many interesting projects are underway to visit in a day and it was necessary to probe haphazardly. An adequate review would take a number of days.

The Welding Division is engaged in a wide variety of activities and is generally well equipped. One study is underway to relate the controllable parameters in electron beam welding to weld defects, especially in deep penetration welds. Materials under study are semikilled steel and Al-An-Mg alloys. The defects of interest are penetration irregularities, porosity, spike formation, and the cracking which may occur at any assortment of boundaries (fusion line, near blow-holes, bead line etc.). The controllable variables include changes in the electron beam gun, vibration, change of feeder material, etc.

There is also some interesting work going on in underwater welding. A pressure chamber is available for tests of the plasma arc weld process. Pressures equivalent to a water depth of 300 meters (31 kg/cm^2) can be duplicated. According to Dr. Michio Inagaki, who conducted the tour, plasma arc welding is especially attractive in deep water (100-300 meters). Stick welding and GTA welding are satisfactory up to 100 meters, but problems with arc stability are encountered at greater depths.

NRIM developed a controlled pressure system for butt welding of pressure tubing for atomic energy plants. Gas pressure in the tube is controlled to provide a delicate balance between surface tension, gravitational forces and arc force during this TIG welding operation. This equipment has now been produced commercially by Mitsubishi Electric Corporation under the trade name "Melomotic."

A tensile restraint cracking test machine of 1000 tons capacity is in use also at NRIM (and in fact was developed by NRIM to investigate the cold cracking of welds by hydrogen). A sustained load is the major feature, and rather massive tests can be conducted. The data are plotted as typical static fatigue data – mean tensile stress in the weld versus time of sustained load. The time-to-failure and threshold features of the curves are used to show such effects as weld temperature, preheat and postheat.

A machine designated as "Weld Thermorestor" was shown which is used to simulate weld thermal cycling, stress of strain during welding, and other welding conditions in a controlled atmosphere, which may include hydrogen, moisture and argon. A high frequency heating system is used. The machine can be controlled to simulate a variety of thermal cycles and can produce constant load or constant strain. This machine, also developed by NRIM, is available commercially now, and at least one has been sold in the United States (University of Michigan, according to Inagaki). The Welding Division also has equipment for the plasma jet spray coating of such materials as alumina and zirconia on Ni and Mo to improve resistance to heat and wear. No results were presented.

The Creep Testing Division is conducting the most extensive collection of data on commonly used engineering alloys in the world. There are literally 1100 creep test machines collecting data on 3500 individual specimens. The philosophy is not only to collect representative creep data on the various high temperature alloys but to establish the statistical spread of properties between different parts of a heat, between different heats, and between heat made in different companies. All industrial high temperature alloys plus several new alloys each year are tested at a variety of temperatures, so far in air. Tests have been run for times as long as 60,000 hours (8 years), and even longer tests are under way. Temperatures range to 1200°C depending on intended service temperature. One investigation

was described. A study was made of the effects on stress-rupture of differences in cross sectional shape among specimens of identical cross sectional area. The results indicate that material inhomogeneity is a larger effect than the shape factor.

The Fatigue Division is also applying the massive assault approach to the prediction and control of fatigue cracking in commercial alloys. Special emphasis is on 1) fatigue strength at elevated temperatures, 2) fatigue strength of welded members and 3) statistical variations in fatigue strength. Again literally thousands of specimens are tested to assess the probability of cycles to failure at various frequencies and temperatures. The S-N curves produced show the confidence limits to the designer who may then exercise the desired degree of conservatism as related to cost and structural performance. Various types of machines are used including rotating beam, push-pull and reverse torsion. One push-pull machine is capable of 150 ton. Another machine permits combined axial and torsion tests. Both high and low cycle fatigue tests are used to evaluate alloys at temperatures to 800°C. High cycle fatigue tests run to 100 million cycles.

In one investigation with austenitic stainless steel the plastic strain range was plotted versus cycles to failure at various temperatures. The steel failed intergranularly at low strain range but transgranularly with larger plastic strain range.

The High Strength Materials Division interests as outlined by Dr. Y. Kawabe are in the development of both high strength and ultra high strength steels. Six general areas were described as follows:

1) Low alloy steel development in the high strength range. Examples are 4340 and H-11.

2) Fatigue behavior in the marine environment of high strength steel (for the present, however, tests are conducted only in air).

3) Steels for deep-diving submersibles. The Japan deep sea rescue vehicle under design was originally intended to reach 6000 meters, and steels such as the U. S. Steel 10 Ni - 8 Co. steel were of interest. Problems in dealing with the heavy section related to reproducibility, stress corrosion cracking, fatigue and fracture toughness encouraged a revision of the goal to 1000 meters. For the latter goal, steels similar to HY-130 are of interest.

4) Maraging type steels and particulary with respect to embrittlement by hydrogen.

5) Cryogenic steels for use at liquid He temperatures.

6) Extremely high strength maraging steel (400 ksi) for potential use in centrifuging machines for the concentration of uranium isotopes.

In individual discussion, Dr. T. Aoki first described his work on delayed fracture crack growth (K_{Iscc}) of high strength steels (4340 tempered at 250°C and 430°C and 4320 tempered at 200°C) in distilled water. Little temperature effect was noted on the value of

K_{Iscc}, but the terminal fracture toughness parameter K_{I8} calculated by measuring the crack depth at the onset of fast fracture increased rather markedly with temperature in both of the steels tempered at 250°C and 200°C. This was observed to be caused by intergranular crack branching as temperature increased. Crack growth rate was dependent on stress intensity factor for the steels tempered at 250°C and 200°C, but independent of stress intensity for the steel tempered at 430°C. An activation energy of about 9000 cal/mol was measured, in all cases, but a correction factor was applied to compensate for the effects of crack branching. Aoki also observed discontinuous crack growth. The intervals between steps were controlled by the thermally activated process with the 9000 cal/mol activation energy.

Work was also described by Aoki on the role of pitting in the stress corrosion cracking of martensitic stainless steel. A 13 percent chromium steel was studied. The corrodent was 3.5 percent NaCl saltwater and the specimens were smooth and electrochemically polarized. With anodic potential, most stress corrosion cracks initiated at corrosion pits, and the time for pitting accounted for most of the time to failure. As might be expected, the cracking process was relatively independent of applied potential.

At constant anodic potential, crack initiation time decreased with applied stress. The depth of pit at which stress corrosion cracking commenced was found to decrease with increasing stress. Furthermore there appeared to be a threshold pit depth required before cracking could be initiated.

Papers covering this work have been submitted for publication by Japan Iron & Steel Institute. The first of these will appear in June 1977.

Dr. T. Saito discussed his work on the toughness of Ni-Cr-Mo steels in the as-quenched condition (see Transactions ISIJ *16* 325 (1976)). After determining that the fracture toughness parameter K_{Ic} could be obtained from the experimentaly determined J integral value, Saito investigated the effects of prior austenitic grain size on fracture toughness. Fracture toughness was found to be relatively invariant with increasing grain although tensile properties deteriorated. At very large grain size, however, fracture toughness decreased abruptly and the fracture mode changed from transgranular to intergranular. Seeking to explain the relative insensitivity of fracture toughness to austenitic grain size, Saito notes a correspondence of fracture toughness with the size of the dimples on fracture surfaces which initiate at small second phase particles. Austenitic grains larger than this interparticle distance would not be expected to have a large influence on the fracture process.

Saito is currently looking at the fracture toughness in two phase materials, in particular 4330 steel quenched from within the stable austenile + ferrite region of the equilibrium phase diagram. Some structures have been obtained which are quite tough, but the tensile properties are not spectacular. This work has been accepted for publication in Trans. ISIJ and probably will appear in March 1977.

Dr. Y. Sumitomo discussed interests in the hydrogen embrittlement of iron alloys, especially interactions of hydrogen and dislocations. He is studying an alloy of 0.001 C, 9.87 Mo, 0.003 S, balance Fe, with the idea of isolating for study the iron-molybdeum (Fe_2Mo) precipitation process which takes place in more complex alloys. Sumitomo applies a tensile

strain, then commences electrolytic charging. Unlike the case of purer iron alloys, the introduction of hydrogen *steepens* the stress-strain curve. A change from cross slip to planar slip is observed. Sumitomo concludes that the slip processes are changed by alloying elements which in turn change the response to hydrogen. Tests are now underway with Fe-Si and Fe-Al alloys.

Dr. Y Kawabe described some of his efforts to produce tough 280 kg/mm^2 maraging steel through control of microstructure (see JISI Vol 62 No. 9, 1976). The steels of interest are highly alloyed (13 Ni, 15 Co, 10 Mo, 0.1 Al, 0.2 Ti) to achieve high strength, and the precipitates are therefore difficult to dissolve. Kawabe has studied the effects of higher solution treatment temperatures (850 to 1250°C) upon the tensile properties and fracture toughness.

The fracture toughness parameter K_{Ic} increases as the solution temperature increases despite grain size increases which deteriorate the tensile properties and ductility. As the fracture toughness increases, there is a shift from dimple fracture surfaces to quasicleavage fracture surfaces, the reverse of the usual relationship between fracture mode and toughness. Kawabe believes the observations reflect the dissolution of the precipitates which are regarded as more deleterious to fracture toughness than is large grain size. Large grain size, however, does deteriorate the tensile properties and ideally the preciptates would be dissolved but the grain size would remain small. Toward this goal Kawabe has been studying thermomechanical treatment and a variety of cyclic heat treatments. There has been some success but these treatments are complex and expensive and therefore the work continues.

Dr. M. Sumeta stated that he will be studying the fatigue of high strength steels in seawater in the future. He was therefore very interested in the related work underway at NRL. He intends to study steels such as HY-130, precipitation hardening steels, maraging steels, 9 Ni-4 Co steels and HY-180 type steels. The tests will be in air and seawater, and the specimens will in some cases contain sharp notches.

Dr. M. Inagaki, head of the Welding Division, is active in committee work both in Japan and internationally. He chairs the Class Structural Steel for Welding Committee of the Steel Division of the Japan Welding Engineering Society. In this capacity he represents Japan at assemblies of the International Institute of Welding. For example he presented a report on the study of cold cracking with the implant test at a meeting in Australia in August, 1976 (IIW Do. IX-970-76). Other concerns and studies of the committees are lamellar tearing and fracture in heat affected zones.

THE UNIVERSITY OF TOKYO

George Sandoz

The University of Tokyo is about 100 years old and was the first in Japan to orient itself toward the Western World. The first classes in science and technology were in fact taught by foreign professors who were employed to introduce these subjects which were not at that time advanced in Japan, at least compared to European technical levels. With this headstart, the University of Tokyo led the way toward westernization and apparently has educated many of the nation's leaders in government and industry. The standards of admission are extremely high and the examinations upon which entrance is based absolutely are referred to as pure "hell."

As a matter of firm policy, the University of Tokyo remains outside of partisan politics. Members of the faculty serve as special advisors or on committees of agencies such as the Science and Technology Agency, Ministry of Education, Ministry of Transportation, Ministry of Construction and the Environmental Agency. The two professors visited, Professor Y. Asada and Professor K. Iida, are for example heavily engaged in research associated with pressure vessel technology and shipbuilding, and they interact directly with such organizations as the Power Reactor and Nuclear Fuel Corporation and the Ship Research Institute (both governmental organizations).

Professor Asada is associated with the Department of Mechanical Engineering and is pursuing several problems in high temperature low-cycle fatigue and on cyclic strain induced plasticity, strain induced creep and recovery. For example he is currently studying the effects of hold time and strain rate on low cycle fatigue of type 304 and type 316 stainless steels at 650°C. This temperature is of interest because it reflects the reactor temperatures where type 316 may be used as a cladding material. The test specimens of Asada are of the hour-glass type, 6 mm in diameter. The load cycle is triangular and involves both tension and compression, but the holding periods (of one to sixty minutes) are always during tension. Tests are conducted in a vacuum of 1×10^{-6} torr.

One paper on their work will be presented by Asada and several collaborators before the 3rd International Conference on Pressure Vessel Technology to be held 19-22 April 1977 in Tokyo. Other papers have appeared previously (see Annual Report of the Engineering Research Institute *31* 91 (1972), Proceedings of the International Conference on Creep and Fatigue in Elevated Temperature Applications, Phil Sept 1973, Sheffield, U.K. 1974).

Asada was most interested in the work of Shahinian and others at the Naval Research Laboratory. Shahinian has attacked similar problems but measures crack growth rates in precracked specimens. Asada has considered the effects of notches (Proceedings of the 2nd International Conference on Pressure Vessel Technology, San Antonio, Texas, 1973) but apparently leaves crack growth rates to others at this time. A colleague of Asada at University of Tokyo, Professor H. Okumura is, however, conducting fracture mechanics type tests with crack growth measured optically.

The work of Asada and others on plastic strain was presented in part before the International Conference on Creep and Fatigue in Elevated Temperature Applications, Philadelphia, 1973. A new paper on "Accumulation of Longitudinal Strain Under Cyclic Torsion" wil be presented before the 4th International Conference on Fracture, 19-24 June, Waterloo, Canada. (It appears that Waterloo will become a Japanese enclave, to judge from the numbers planning to attend.)

The plasticity work of Asada is done on several rather intricate but well-conceived machines which provide torsion plus push-pull strain. By measuring the push-pull plus the torsional strains, the total strain can be determined and comparisons made with theory. A hollow cylindrically shaped specimen 42 mm in diameter is used (currently type 316 stainless) which costs $500 each.

Professor K. Iida is associated with the Department of Naval Architecture and this visit began with a tour of the laboratory. The laboratory features an assortment of machines designed to test specimens and components for fatigue resistance, brittle fracture resistance and general strength characteristics. One machine, for example, can apply 600 tons to brittle fracture specimens, thus allowing sections of several inches of thickness to be tested. There is also a 50-ton cyclic load bed to study high-cycle fatigue and another 50-ton bed to study low-cycle fatigue, under servo control. A 400-ton Amsler type loading machine for static loads was apparently the scene of Professor Kanazawa's famous double tension test developed some years ago. This test features a small tensile "ear" with crack starter notch machined from but still attached to the larger specimen to be tested for resistance to brittle fracture. The small "ear" serves to start a crack traveling into the larger section. The test, similar to the ESSO and Robertson tests, is very expensive but was useful in earlier investigations.

It was interesting to see some of the smaller fatigue machines and specimens which were duplicates of the fatigue machines used earlier by E. Lange of the Naval Research Laboratory to test unnotched specimens in low-cycle fatigue. Lange is well known to these investigators at University of Tokyo. These particular machines are being used to test welded joints of 9 percent nickel steel for pressure vessel carriers of LNG ($\approx$ -160°C, 1.5 psi gage). The Department of Naval Architecture is also studying acoustic emission as a means of following the processes of fracture. One test observed in progress involved a 4-point bend specimen. The acoustic emission sensors were being used to follow the plastic deformation and cracking processes.

Iida presented a tall stack of reports, many of them very current, which shows that he is a most prolific researcher. His high stature as evidenced by his invitations to serve on high level committees, boards, and international advisory and control or regulatory groups is very understandable. One of the subjects on which Iida has published extensively is on low-cycle fatigue, how cracks are initiated and grown by this process, and how this relates to design and fabrication processes, especially of large ships and pressure vessels. He has been interested in the related areas of the effects of notches and weld defects on fatigue crack initiation and propagation. The fatigue spectrum, or shape of the fatigue cycle, has also been investigated. Recently he has been working with Dr. M. Kawahara of Nippon Kokan Kabushiki Kaisha to develop an expression for the propagation rate of a fatigue crack from a surface flaw. This work (see previous report on visit to Nippon Kokan K.K.) attacks the problem of variation in

crack front morphology depending on stress system (bending or tension) (see IIW Doc 13-802-76, IIW Doc 13-790-75, IIW Doc 13-801-76).

Iida and collaborators presented papers at the Third Acoustic Emission Symposium, Tokyo, 1976, describing acoustic emission during fibrous brittle fracture and during the low cycle fatigue of hemispherical pressure vessel models. One interesting finding was that in the case of brittle fracture not accompanied by a fibrous crack, there is almost no previous signal by acoustic emission, hence no way of detecting the initiation of brittle fracture. However most common structures do not fail in a completely brittle manner, and acoustic emission does signal the initial fracture processes in these cases.

Most recently, Iida presented a paper, "Comparison of Fatigue Strengths of Steels Under Deflection Controlled Bending and Strain Controlled Axial Load Cycling," at the 2nd International Conference on Mechanical Behavior of Materials, 16-20 August 1976, in Boston. A paper on "Low Cycle Fatigue Strength of Steels and Welds in Relation to Static Tensile Properties," is scheduled for presentation at the 4th International Conference on Fracture at Waterloo (where else?), 19-24 June 1977. This paper, in collaboration with E. Fujii of the Ship Research Institute in Mikota, claims to show that the total strain amplitude in reversed strain cycling can be predicted by static fracture ductility (RA) and ultimate tensile strength within an accuracy of 40 percent. The visible crack initiation life must also be known.

Both Iida and Asada were apologetic about the lack of modern equipment in their laboratories, particularly with respect to the computerized control of tests and data retrieval and analysis. However, the impression was that there is much in the way of human ingenuity at University of Tokyo now, which a flood of new machines might erode.

YOKOHAMA NATIONAL UNIVERSITY

George Sandoz

Several departments of the Yokohama National University faculty of engineering were visited on this occasion. The principal host was Professor S. Oki, who did much more than was expected or required for a satisfactory exchange. There was not much discussion of the history of this institution, but it was established that only master's degrees are conferred and that the school is in process of moving to an entirely new campus some 10-15 kilometers away. The move will be completed in 3 or 4 years. Meanwhile, the existing campus is somewhat run down and generally neglected insofar as cosmetic values are concerned.

Professor Oki described the KOZA system of Japan which is a research or professorial unit consisting of a professor, associate professor plus assistants or lecturers and graduate students. The KOZA is composed of four people. In a given university, each KOZA is granted an identical amount of money for research, although there are differences between technical departments and liberal arts departments. Of perhaps greater interest, there are significant differences in the money allotted (by the Ministry of Education) to KOZA's of different universities. Thus a KOZA at University of Tokyo receives more money than a KOZA at Yokohama University. One determining factor in this is the highest degree offered, and as stated earlier, Yokohama offers only the master's degree.

The usual presentation on activities of ONR and NRL was well received and there was considerable interest in how this system operates within the organization of the Defense Department. There is still some difficulty among the Japanese in visualizing a defense activity which is primarily a thrust at basic science.

Presentations and discussions followed among a number of professors at Yokohama National University. The students of Professor Y. Wada made a valiant effort to explain their work in the areas of hydrogen embrittlement and surface self-diffusion. With respect to hydrogen embrittlement, it was observed, in the case of pure iron, that increasing currents of cathodic charging produced a decrease in the flow stress of tensile specimens. On the other hand, increasing charging amperages on an HT-80 steel (0.09C, 0.24 Si, 0.82 Mn, 0.23 Cu, 0.97 Ni, 0.42 Cr, 0.42 Mo, 0.03 V, 0.002 B) produced a progressively increasing flow stress.

To explain these effects, specimens of an HT 60 steel were charged at 0.2, 1.0, 10, 40, and 100 mA/cm^2 during tensile testing. Specimens charged at 40 and 100 mA/cm^2 were apparently damaged. The "damage" incurred can be explained, according to Wada, only by the interaction between "active" hydrogen and dislocations.

The surface self-diffusion is studied by Wada and his students essentially by studying the rate of smoothing of grooved specimens as a function of temperature. The materials involved have been 17 percent Cr steel, pure Ni and 3 percent Al-Fe. Wada contends that the surface relaxation occurs by volume diffusion, surface diffusion and evaporation-condensation. He favors the mass transfer mechanism due to Mullins, who describes the solution for the smoothing of a sinusoidal metallic surface in vacuum.

Professor Oki described briefly his work on hot tearing and in particular the relation between cooling rate and thermal stress in castings during solidification and subsequent cooling (International Foundry Congress, Belgrade, Yugoslavia, 1969). Oki is preparing a paper on the theory of hot tearing for submission to the Japan Iron and Steel Institute entitled "Theoretical Study of Hot Tearing in Skin-Forming Solidification." He also described some very interesting recent work on the atomic model of crystallization. Basically, he puts many small steel balls on a plate subject to viration, but one end of the plate is vibrated with greater amplitude than the other. By slowly decreasing the amplitude generally, he can show how crystals nucleate and grow. He can also model the processes of melting, by gradually increasing the vibration amplitude. This work has been described in IMONO (FOUNDRY), Vol. 48 No. 8, 1976.

Professor Asakura described work on control of corrosion which his group is doing in the Department of Safety Engineering. Safety and Environmental Engineering has become important in Japan in recent years, and in consequence this new department was created. Early efforts have been directed toward the development of a corrosion rate test meter which measures corrosion rate from polarization at a distance. There are also experiments designed to simulate pollution and the diffusion of pollutants in water. Both the pollutant and the detection of the pollutant are of interest. Future plans include tests of corrosion by pollutants in a stress environment.

Dr. K. Ando described his interesting work in the Laboratory for Materials for Energy Systems. He is interested in brittle fracture problems with pressure vessels and with large oil tankage vessels. He has developed a simplified and cheaper test to assess cold cracking after welding in high strength steel. He has also studied fatigue fracture toughness parameters and describes a fatigue fracture toughness parameter "K_{fc}" which always is lower than K_{Ic}. Both parameters decrease with decreasing temperature. The steels with which Ando is concerned are quite tough and slow crack growth is involved in fracture mechanics tests. He is therefore trying to develop use of the J-integral for such analyses.

Ando is also investigating the initiation of brittle fracture from the defects in welds such as lack of penetration. As a "hobby" he is also interested in the effect of temperature on fatigue crack growth rate and on the plastic zone size near the fatigue crack. Ando is a fully qualified Naval architect as well as a materials engineer. Important papers by Ando appear in 1) Tohoku University Thesis, 1969; 2) Proceedings of 2nd International Conference on Mechanical Properties, Boston, 1976; 3) Journal of Society of Materials Science, Japan, Vol. 25, No. 268, p. 97, 1976.

Professors T. Kamijo and K. Sekine are interested in deformations and annealing textures and upon the influence of texture on stress corrosion cracking of Al alloys in salt solutions. Variations in susceptibility with respect to preferred orientations have been observed. No crackstarter tests have been attempted. Pertinent papers are published in 1) Journal of Safety Engineering, Yokyhama National University, Vol. 14, No. 2, 1975; 2) Transactions J. I. M., Vol. 12, No. 3, May 1971; and 3) Transactions J. I. M., Vol. 17, 1976.

Kamijo also states that the ductility of face centered cubic metals depends on the stacking fault energy, temperature and initial orientation. Kamijo has studied the longitudinal

work hardening rate of Al, Cu, and Cu-Al alloys. The addition of Al to Cu decreases stacking fault energy and the frequency of deformation twins decreases.

Professor Iguchi is studying the non-stoichiometric states of transition metal oxides. He has returned only recently from the University of Bradford, near Leeds, where he studied for two years with R. J. D. Tilley. The work has resulted in one publication in the Transaction of the Philosophical Society of the Royal Society of London ("The Elastic Strain Energy of Crystallographic Shear Planes in Reduced Tungsten Trioxide"). The paper will appear in May 1977. A subsequent paper entitled "Strain Energy Between Parallel {001} Crystallographic Shear Planes in Reduced Tungsten Trioxides" will be submitted to Philosophical Magazine soon.

Iguchi's work is basically the calculation of the elastic strain energy due to crystallographic shear on planes lying upon the {102}, {103} and {001} planes. Calculating the cases of both isolated shear planes and for pairs of shear planes he is able to estimate the elastic strain energy per unit volume for crystals containing ordered arrays of crystallographic shear planes. Iguchi calculates that the magnitude of the elastic strain energy of the three planes is of the order $\{001\} > \{102\} > \{103\}$, and that at small crystallographic shear plane spacings the curves of elastic strain energy versus crystallographic shear plane separation takes the form of successive peaks and valleys. Iguchi claims to have shown experimentally that the elastic strain energy does indeed play a significant role in controlling the microstructure.

Dr. T. Endo, an associate of Professor Kamijo, described briefly some work on the effects of superimposed ultrasonic vibratory stress on static flow stress. Apparently Endo is seeing some mechanical effects as a result of superimposed ultrasonic vibration applied to specimens otherwise under routine tensile testing. The effects have been seen on a wide variety of metals and alloys (Al, Cd, Cu, Cu-7Al, Cu-Zn, weld steel, Mg, Mo, 17-4 PH, Pb, Ta, Zn and W). A decrease in static flow stress results to varying degrees in all of these materials when ultrasonic vibration is imposed. Effects on work hardening rate, hardness and fracture resistance (probably ductility) are observed in some instances but not in others. There are no effects of environment (air, H_2O, CCL_4) but frequency and temperature may have an effect. It was not entirely clear just which results are Endo's and which were results he obtained from the literature, but Endo is working in this area. The immediate goal is to determine the role of dislocations and whether a change in average dislocation density due to ultrasonic vibratory stress can explain the observations. Endo is working on Fe-3 Si alloy.

The general impression of Yokohama University is very favorable. One sees a faculty which is dispersed in age, but energetic and working hard. The students also are intense, serious and appear to be obtaining a sound education. As is common everywhere there were complaints over forced direction into practical problems.

RESEARCH INSTITUTE OF NIPPON KAIJI KYOKAI

George Sandoz

A visit to Nippon Kaiji Kyokai head office in Akasaka had been scheduled previously, and at the instigation of Dr. K. Iida of the University of Tokyo a visit was also arranged to the Research Institute located at Mitaka, immediately adjacent to the Ship Research Institute of the Ministry of Transportation. Nippon Kaiji Kyokai is an international classification society which promotes safety at sea. The Society is a member of the International Association of Classification Societies (IACS) consisting of nine major classification societies. Experienced surveyors of the Society survey ships with a view to certification for construction and safety. The results of such inspections are published annually in the Register of Ships. The highest class of certification is designated NS* and is recognized by both London Underwriters and the American Marine Insurance Clearing House. The Society serves essentially the same function as the American Bureau of Shipping. In 1975, 3729 ships aggregating 50 million tons gross representing 40 nationalities were classed by the Society.

The Society maintains the Research Institute to help ensure that its technical rules and requirements are rational and up-to-date. The results and focus of the Research Institute are always related to the behavior of Nippon Kaiji classified ships in service, which range all the way up to 500,000 ton tankers.

The Nippon K. K. Research Institute is organized into three sections: ship hull, machinery and material research. There is also a modest computer research section attached. Current materials activities focus on 9 percent nickel steels, maraging steels and aluminium alloys and their behavior in air and in saltwater. There is no activity at present with respect to precipitation hardened or other high-strength steels. Fatigue and crack propagation by fatigue in hostile environments is the chief concern. Massive carriers for LNG, ore, oil and lumber are the related interests.

One interesting paper was described which will be published eventually by the Japan Society of Mechanical Engineering. This paper entitled "A Study on Fatigue Crack Growth from Surface Flaw" by J. Arai, Y. Ino and H. Iwaki was an outgrowth of research on alloys for use in LNG carriers (9 Ni steel and Al alloy). Liquid nitrogen was used to control test temperatures, and it was noticed that specimens behaved differently depending on whether residual nitrogen was or was not present during the test. This triggered an investigation, with the following results:

Crack growth rate in Al-Mg alloy A 5083-0 is lower in nitrogen than in air. A decrease in temperature to -162°C also decreases growth rate. The environmental effect of nitrogen is, however, the greater. Additionally, the different environments produce a different shape of crack front. The surface crack fronts are semi-elliptical in nitrogen gas and semi-circular in air.

The observations are explained by asserting that reversed (cross) ship is easier in nitrogen than in air. The different crack front shapes are explained on the basis of easier

crack closure in nitrogen than in air. Air impedes the closure of cracks by cross slip (reversed slip) because of the impurities formed on slipped surfaces.

A tour of the Research Institute showed further advanced, large-scale, testing machinery. A large fatigue machine involved a servo pulse of 10^{-4} sec and a capacity of 400 cps. Diagramed loading is possible. Data from on-board records of fatigue loading can be programmed into the machine to duplicate the load spectrum of service conditions on test specimens. A hybrid analog and digital computer is available for analysis of the dynamics of vibration and impact.

A number of large rotating-type fatigue machines were shown. Some of these involve bending and torsional fatigue and fretting as designed to duplicate crackshaft service. A large 300 ton low-cycle fatigue test machine was also observed. Fatigue and crack propagation tests are made on very large specimens – up to 700 x 30 mm. Cryogenic control is through use of nitrogen gas which is used liberally. The cost of nitrogen gas alone runs to 10 million yen per year (30-40 K).

The general impression of the Ship Research Institute and of Nippon Kaiji Kyokai Research Institute is that first class, practical research on the behavior of ships with respect to design and materials is going on. There does not appear to be any significant interest in the metallurgical structure of base plate or welds. The behavior of the designs assuming a material continuum is the central interest.

NIPPON KAIJI KYOKAI HEAD OFFICE

Following a visit to the Nippon Kaiji Kyokai Research Institute, this one to the Headquarters Office was perhaps redundant. Nevertheless, interesting discussions were held with several people. Dr. Y. Akita, Vice President of Nippon K. K. described some current activities. He is the Chairman of the International Symposium on Practical Design in Shipbuilding to be held in Tokyo 18-20 October 1977, and he is very busy arranging the details of this meeting.

The only directly technical contribution of the day involved a demonstration (by Dr. Shin-Ichi Kaku, Head of Planning Division) of an extremely compact ultrasonic NDT test device. This was developed under sponsorship of Nippon K. K. by Tokyo Keiki, a company in Tokyo. The compact device weighs perhaps one-half pound and is readily carried by inspectors to the most difficult areas for ship and piping inspection. The device checks for cracks and poor penetration in welds, to a depth of two inches.

THE SHIP RESEARCH INSTITUTE

George Sandoz

Under the gentle persuasion of Professor K. Iida of the University of Tokyo, the writer visited the Ship Research Institute of the Japan Ministry of Transport. The Director General is Dr. N. Ando, and under his management are Divisions concerned with ship propulsion, dynamics, structures, welding and fabrication, engine development, marine engines, ship equipment, nuclear ships, oceanographical engineering and physical engineering. Although the Ship Research Institute was originally established in 1916, the present organization apparently took form in 1963. It was at this time that the present Ship Research Institute with the ten Research Divisions and two Branches (at Osaka and Tokai) was formed as a technical resource of the Ministry of Transportation. The Institute does research in areas of concern on ships which are indicated by the Division functions. The results of this research are published in "Report of the Ship Research Institute" and "Papers of Ship Research Institute."

In the Ship Equipment Division, under the direction of Dr. K. Ohnaga, some experiments on alternate-immersion corrosion were shown (by Dr. S. Naito). Specimens are contained in cells and subjected to fatigue in bending to maximum stress of 25 Kg/mm^2 while cycling between 15 and 150 cpm. The cells permit alternate filling and emptying with synthetic seawater, so that the 1/8" x 1/4" specimens are subjected to both reverse bending and alternate immersion. Temperature is controlled, and up to 12 specimens may be tested simultaneously. Specimen failure is monitored by both weight loss and fracture. At least one paper on this work is published ("Corrosion of Steel by An Alternate Immersion Method," Ship Research Institute Voi. 13 No. 2, 1976, p. 76 by K. Ohnaga, S. Naito and T. Shibata). The work is intended to apply to problems with corrosion of the ballast tanks of tankers and ore carriers. The work to date indicates rapid increases in corrosion rate with increasing water and air temperatures, but not much influence of the fatigue stress.

In the Division of Ship Structures some massive test facilities were observed. One test was underway of an entire section of ship at 1/10 scale. This ship section test component, representative of an oil tanker, was subjected to both bending stresses and compressive stresses at the sides, as would be encountered in ocean service. Hydraulic jacks were used liberally to apply the desired multiple stresses. Massive fatigue testing machines were also seen. One Schenk Fatigue Machine of 30 ton tension or compression capacity had been modified to provide 200 tons in tension or compression.

On a more conventional scientific laboratory slant, experimental apparatus for the measurement of stored energy resulting from low-cycle fatigue was shown. A differential thermal analysis calorimeter is featured. The specimens are 3.5 mm diameter rods deformed by fatigue. No cracking is involved, hence there is no effort to measure directly fatigue-produced stored energy at crack tips.

The Ship Research Institute Welding and Fabrication Division directed by Dr. A. Kanno is concerned both with non-destructive test concepts and, again, with massive tests for fatigue resistance and brittle fracture resistance. Kanno is especially interested in radiographic techniques to detect cracks. Ultrasonic methods are also under study. The laboratory has a

300 KV Betatron for advance radiography of thick plate and welds (up to 50 mm). Kanno is studying the means of measuring and detecting the cross section of natural cracks by X-ray. A cylinder containing a natural crack is inserted into a close fit cylindrical hole in a thick plate. By rotating the cylinder during radiography Kanno is trying to establish the relation of defect width which appears in the radiograph, with crack morphology and orientation.

The massive equipment in the Welding and Fabrication Division features a push-pull type 3000 ton fatigue machine only 10 years old. A 15 million electron volt Betatron is available for *in-situ* radiography during these fatigue tests of massive plates and welds. There is also a tensile machine for brittle fracture tests, maximum capacity 4000 tons. This machine was installed primarily to test steels for nuclear pressure vessels.

A large test pressure vessel tank, three meters in diameter, was shown. This tank was being subjected to hydraulic pressure, and acoustic emissions from a small submerged notch were being studied. A minicomputer gives a graphical display of the location of flaws. The particular detector used is a Nortec AE Δ T Flaw Detector, NDT 256. This Richland, Washington firm is at least one example of an equipment sale to Japan. The Ship Research Institute has under construction machines to test dynamic fracture toughness. These dynamic tensile brittle fracture machines are estimated as three years away.

The Director General of the Ship Research Institute, Dr. Ando, is Secretary to the Organizing Committee of the International Symposium on Practical Design in Ship building to be held in Tokyo 18-20 October 1977. This Symposium will celebrate the 80th anniversary of the Society of Naval Architects in Japan.

A GLIMPSE OF SOME MATERIALS RESEARCH AT THE TOKYO INSTITUTE OF TECHNOLOGY

George Sandoz

Tokyo Institute of Technology (Tokyo Kogyo Daigaku) characterizes itself as the leading institution of higher learning in the field of engineering and science in Japan. After a visit to both the O-okayama and Nagatsuta campuses, the writer would not venture to argue on their "we're number 1" proclamation. The discussions at the O-okayama campus were primarily with Tsutomu Mori, Professor in the Departments of Metallurgical Engineering and Materials Science and Engineering. Professor A. Sato, the Associate of Professor Mori, also participated actively.

Professors Mori and Sato are well known in the international metallurgical community and they both have resided in the United States for various periods, notably in connection with activities at Northwestern University. Professor Mori was a post-doctorate in the Civil Engineering Department at Northwestern University from 1959 through 1961. He was also in residence from 1965 through 1968 in the Materials Science Department. Most recently, he was at Northwestern for two months in 1975 during which period he produced an amazing four technical publications in collaboration with the Northwestern faculty. Another two-month trip to Northwestern is scheduled for the summer of 1977, and it will be interesting to see if this fantastic productivity continues. To complete the Northwestern University connection, Dr. Sato obtained his Ph.D. there in 1971. Professors Mori and Sato have two major current interests: 1) work hardening and recovery of dispersion hardened materials, and 2) stress effects on martensitic transformation and diffusional precipitation.

With respect to the first area, Mori stated that his early theoretical analyses have led him to his current experimental activities. Briefly, he produced a series of papers beginning in 1970 (Acta Met *18*: 939 (1970), Acta Met*20*: 297 (1972), Acta Met *21*: 571 (1973), Materials Science and Engineering, *26* 87 (1976)) in which he and his collaborators developed a theory of dispersion hardening which reconciles calculations of work hardening by continuum mechanics and dislocation theory. Previously dislocation theory met difficulty in handling elastic constants and particle morphology. The theoretical analyses of dispersion hardening were shown also to be applicable to fiber-containing material (Acta Met *21* 85 (1973)).

The first experimental work appeared in 1975 (Acta Met *23* 85 (1975)). This involved single crystal specimens of copper-containing silica particles (via internal oxidation). The study was of length change and softening by recovery during annealing at 200°C. The observations agreed with the theory.

At present the work seeks to explain the effects of dispersions of particles upon creep. Two students are involved, studying the systems Al - Si and Cu - SiO_2 + BeO. Ordinarly, metals are strengthened as a given amount of precipitate material is dispersed into smaller particles; however this may not be true at elevated temperatures. Mori and his colleagues have shown, for example, that softening during low temperature annealing is sensitive to

particle size. A paper on this subject, "Effect of Particle Size on Low Temperature Softening of Work Hardened Copper-Silica Crystals," has been accepted for publication by Acta Metallurgica. Particles 280Å in diameter resulted in softening after 20 minutes at 42°C whereas 900Å diameter particles produced no softening. Therefore at low temperature small particles strengthen, but at high temperatures where creep is a problem large particles may be preferred.

The student studying the Al-Si system will be concerned with the effects of one precipitate, of variable particle size as produced by heat treatment. The other student, studying the Cu - SiO_2 + BeO system will be involved with a composite dispersion. These systems are produced by the internal oxidation of Cu - Si - Be alloys, which can be produced at the University. It also so happens that the SiO_2 particles grow upon annealing whereas the BeO particles are rather stable. Thus a material can be produced with two dispersions, one with particle size which is stable and the other with particle size which is variable and which can be controlled. Mori hopes to demonstrate that a material which is strong both at low temperatures (fine dispersion) and at elevated temperatures (coarse dispersion) can be produced. The alloys used in the experiments are, of course, selected to simplify the experimental problems. The principles evolved, however, should be applicable to the design of genuine refractory alloys.

Professor Mori's second area of current interest is the effects of stress on martensitic transformation and on diffusional precipitation. Interest in the latter process has focused about the Fe-N system. Iron-0.5 percent N alloys were prepared as single crystals. The crystals were quenched from 590°C to produce a solid solution, then aged at temperatures between room temperature and 100°C, either under stress of various magnitudes, or free of stress. It was found that the α "$Fe_{16}N_2$ precipitate which forms becomes progressively finer and crystallographically oriented with increasing stress during aging. Stress in the [011] direction produces precipitate disks which are perpendicular to the stress if in tension but parallel to the stress if the stress is in compression. Residual stresses also influence precipitation. This work is described in detail in Kinzoku Gakkaishi, *V39* No. 6 (1975).

With respect to the effects of stress on martensite transformation, Mori has shown the existence of a temperature, M_a, which is different from the martensitic formation temperature M_s which obtains in the absence of stress. Deformation of the metal above M_d is by slip, below M_d by transformation to martensite. According to Mori the process involves the motion of partial dislocations. Further details are given in a series of papers. See Acta Met *22* 313 (1974) and Acta Met *24* 853 (1976). A paper entitled "Contribution to the γ - ϵ Transformation of Stainless Steel Single Crystals," by A. Sato, Y. Sunaga and T. Mori has been accepted for publication by Acta Metallurgica.

The visit to the O-okayama campus concluded with a laboratory tour. The highlight was the new Hitachi H-700 200 KV transmission electron microscope, which features the routine attainment of 200 KV and thus offers better resolution.

The meetings at the Nagatsuta campus took place at the Research Laboratory of Precision Machinery and Electronics, one of the research institutes attached to the National Universities. The mission of this Laboratory is to study the basic theories in precision engineering and their application to industry. The Laboratory is organized to foster

interdisciplinary interaction among precision machinery engineers, electronics engineers and metallurgists. Among the fourteen Divisions of the Laboratory, the writer visited two, the Materials Sciences Division with Professor Shigetomo Nunomura the principal contact, and the Heat Treatment Division with Professor Tomoo Suzuki the principal contact.

The visit began with a tour of the Nagatsuta campus and the Research Laboratory of Precision Machinery and Electronics in particular. There is an enormous amount of construction of rather impressive building underway at this new and only partially completed campus. The graduate school of the O-okayama Campus is scheduled to move to the Nagatsuta campus in 1977 and the Laboratory of Engineering Materials (another research institute) in 1978.

With the exception of the new electron microscope at the O-okayama Campus, the writer was shown little in the way of sophisticated equipment. In one completed building, for example, the hosts pointed to the spot (very clean and very ready) where the electron microscope will go, if and when the Ministry of Education comes up with the funds.

In the Heat Treatment Division (a refreshing departure from the vogue of inventing pretentious titles), Professor Suzuki discussed briefly a number of activities which are highlighted as follows:

1) Fiber Composites – one student is trying to strengthen polymers with glass and carbon fiber. The goal is light weight coupled with high modulus for aircraft application. No specific results were described.

2) *In-Situ* Composites – the interest is in the effects of thermal cycling on directionally solidified composited such as Al-Ni3Al. Such cycling produces severe dimensional changes in aligned phases according to Suzuki. This may complicate the prospective use of such materials in high temperature applications involving thermal cycling. There is severe growth and twisting of the Al-Ni3Al composite, for example, after a few thousand 5-10 minute cycles from room temperature to 500°C. The work being done involves lower melting, experimentally tractable alloys, but the hope is that the fundamentals of controlling and understanding the dimensional instabilities which are developed will be applicable to the design of refractory directionally solidified composites.

3) Properties of Ni3Al – there is an interest in studying fundamentally the anomalous increases in hardness of this compound with increasing temperature. The hardness of this important phase (γ') in high temperature alloys may increase by a factor of two or three between room temperature and 800°C. No specific results were described.

4) Hydrogen effects – the effects of hydrogen on properties such as electrical resistivity and upon M_S temperature are being studied. An apparatus to charge gaseous hydrogen into specimens at 200 atmospheres and 800°C has been assembled. An internal quench tank is an added (and necessary) feature. Suzuki has published a paper, "Effect of Hydrogen on the M_S Temperature in Fe-Ni and Fe-Ni-C," First Japan Institute of Metals International Symposium on New Aspects of Martensitic Transformation, Kobe, May 10-12, 1976 (Supplement to Trans. JIM, V 17 (1976). The paper is in collaboration with J. C. Shyne of the Division of Materials Research, National Science Foundation. This work, which

shows that hydrogen decreases M_S comparably to other interstitial solutes such as C or N, was done in part while both authors were at Stanford University.

In the Materials Science Division, Professor Nunomura discussed studies in fatigue crack growth rates of alloys. The goal is to relate the effects of metallurgical structure (as influenced by composition and heat treatment) and such mechanical factors as mean load, stress intensity factor range, periodic overload, etc. Nunomura is also attempting to determine fatigue threshold rapidly by a programmed decrease in ΔK (crack arrest). At the same time he denies the existence of a fatigue threshold, but the contradiction appears to be a matter of definition with respect to micro and macro observations. The experiments are currently being performed with 7075 Al specimens. Crack growth rate is monitored by a time-lapse photography method, which perhaps highlights the imbalance between equipment and buildings.

Another novel approach to measure the plastic zone directly in certain steel alloys was also described. The trick is to stress or fatigue a precracked specimen in the temperature region between M_S and M_d. The increased stress (strain) in the plastic zone promotes the transformation to martensite, and the martensite then serves to decorate the plastic zone. According to Nunomura the reverse plastic zone can also be delineated. This work has been summarized in paper entitled "Direct Measurement of Plastic Zones in Side Grooved Fracture Toughness Specimens" to be presented at the Fourth International Congress on Fracture, Waterloo, Canada, June 19-24, 1977.

NIPPON KOKAN KABUSHIKI KAISHA

George Sandoz

Nippon Kokan K. K. is one of the gaint steel making, and shipbuilding companies in Japan. The company is also deeply engaged in heavy industry construction and engineering, plus a few peripheral activities such as fertilizer manufacture. Dr. Kazuo Horikawa was the principal host for my visit to the Technical Research Center in Kawasaki, and discussions were held with approximately ten other technical persons as well.

The meeting began with private discussions with Dr. Horikawa, Technical Counselor to Nippon Kokan K. K. He related his experiences during World War II as a Japanese Naval Officer engaged in industrial pursuits, notably the development of improved armor plate for ships. He stated that he was invited to work with the U. S. Navy after the war, presumably because of his accomplishments for the Japanese Navy, but he declined in fear of entering the "enemy" country at that time.

Following these preliminary amenities, the writer presented a summary of the ONR-NRL research organization and activities before a group of technical specialists. There were many questions, and particular interest was shown in the operation of the contract research programs. They found the concepts of brutal competition, Navy purposes and the lofty pursuits of academic basic researchers difficult to reconcile. This is perhaps not too startling since some people in the United States are equally baffled.

Dr. Horikawa reviewed briefly the activities and organization of Nippon Kokan K. K. Historically, the company was established to make steel pipe, but thereafter expanded into steel making and heavy industrial functions. Today the iron and steel making is the largest percent of sales (75-80 percent) followed by ship building and heavy industry (each about 10 percent of sales). Approximately 20 million tons of steel are produced annually at the Fukuyama Steel Works and about 6 million tons at the Keihin Works. The company also manufactures ferroalloys (ferrochrome at Toyama and ferromanganese at Niigata). Ship building is located in three plants with capability of up to 500,000 ton ships at Tsu, 160,000 ton ships at Tsurmi and 27,000 ton ships at Shimizu. Heavy industry activities are also concentrated at Shimizu.

The Kehin Steel Works, built over 60 years ago, is now burdened with obsolescence and pollution problems. Nippon Kokan K. K. is solving this by constructing an entirely modern steel works at Ogishima, an artificial island created in Tokyo Bay by hauling sand from Chiba, approximately 40 kilometers away. Connection to the mainland is by bridge and tunnel. When the new facilities are completely operational, the outdated facilities are scheduled to be dismantled. There will be some consolidation of facilities for pipe mills and part of the area will be sold for the development of the Yokohama-Kawasaki area.

The company claims special strength because of its integrated steel making, ship building and heavy industry interests. Special achievements are the computerization of manufacturing controls, the development of the first UOE 56 inch O.D. pipe mill, the first 100 inch O.D.

spiral weld pipe (1975), and the development of continuous casting of slabs, blooms and billets directly from basic oxygen furnaces. All of the research in the company is conducted at the Technical Research Center. The work undertaken may be basic, but is intended to relate to the three Steel making, Shipbuilding and Heavy Industry Divisions. The activities are organized into six research departments plus four attached research organizations in the Tsurumi, Keihin, Fukuyama and Tsu areas and range from coal research to steel processing, steel properties, coatings and corrosion, welding and ship structures. Product research related to steel, welding and surface treatment has led to the development of high strength steels for ships, construction, tubes and sheets for deep drawing. There is pride in large scale tests of welded members up to 220 mm in thickness at temperatures between -70°C and near absolute zero. The results are applied to welding techniques for liquified gas storage vessels for cryogenic service. Developments of continuous heat treating and coating processes have been pursued. As a leading pipe manufacturer, NKK is studying plasma welding, LNG tank piping and the means of welding complex piping systems.

The Technical Research Center is equipped with a wind tunnel to study the effects of wind pressure on long-span bridges and other exposed steel structures. Wind velocity of 0.3 to 50 m/sec can be generated across a 15 m test area. There is also a large circulating water test tank for analysis of the resistance to waves, currents and pressure in a fatigue-producing motion sequence. Endurance tests on large hull segments are made.

Presentations were made by several members of the Technical Research Center. First Mr. I. Matsushima described the work of the Corrosion Laboratory. Matsushima is a general corrosion expert and has published widely. He spent two years in the 1960's at MIT where he published papers with H. H. Uhlig. Their work was on hydrogen cracking and stress corrosion cracking of stainless and precipitation hardening steels. At NKK he has been concerned with a number of problems. For example, he has written (Nippon Kokan Technical Report-Overseas, Dec. 1974) on the improvement in resistance to polythionic acid of stainless steel type 321 by increasing the ratio of Ti to C and by annealing at 1000 to 1500 C. This corrosion problem was encountered in the petroleum industry. He has also published on the subject of weathering steels, with emphasis on the structural and environmental factors which control the protective nature of the rust film which forms in such alloys (see Corrosion Science, *11* 129 (1971) and Boshoku Gijutsu, *23* 177 (1974)). More current interests are on the cathodic protection of coated pipeline (presented at Corrosion 173, NACE) and the corrosion of metals in sulfurous exhaust gases from sintering plants (presented at Corrosion 175, NACE, in Toronto, Canada). Of perhaps greater interest to the Navy, he has studied the corrosion behavior of metals in geothermal steam power plants (Trans ISIJ, *16* 689 (1976)). It was reported that resistance to corrosion and erosion is improved in hot water and steam well conditions with increasing percentages of chromium, and little corrosion occurs with chromium above 13 percent. Weathering and low-alloy steels, which enhance corrosion resistance in the atmosphere, are not effective in this type of service.

Dr. Masanori Kawahara of the Engineering Laboratory described some of his work in fatigue. The facilities for fatigue studies at the Technical Center are excellent from the standpoint of large component testing. Almost every imaginable type of test is done, from tests of pipe K-joints in a submersible drilling rig, to wave-effect tests of critical ship load-bearing structures. Kawahara has published, for example, on the fatigue strength of a

particular ship structures design (Nippon Kokan Technical Report-Overseas, Dec. 1975). He is also scientifically inclined and has written on the retardation of fatigue crack growth in a HT80 steel from overload in the fatigue cycle (Engineering Fracture Mechanics, *8* 507 (1976)). Very recently he has written on growth of fatigue cracks from a surface flaw. He shows that flaw growth from a surface flaw produces a different shape crack front, depending on whether the specimen is strictly tensile or involves a bending moment. This differs from the ASME code which assumes that both crack fronts grow identically. According to Kawahara, it is for this reason that quite often plots of da/dN versus ΔK produce scatter if different specimens are used. Kawahara has developed expressions which he claims overcome the difficulty, and says that he can determine relationships between a (crack depth), b(crack width) and da/dN in specimens subjected to combined tensile and bending loads. These results, which may be very important to an understanding of fatigue crack growth, may be applicable in part to studies of crack growth from stress-corrosion. Kawahara (with M. Kurihara) is presenting this work before the 4th International Fracture Conference, Waterloo Canada, 1977.

Mr. N. Seki and Mr. Oichi next described some problems and concerns with stress corrosion cracking and hydrogen embrittlement. The company has several interests here. Nitrite stress corrosion cracking is a concern in the fertilizer trade. Steels of 40-60 kg/mm^2 tensile strength are involved. Cracking from H_2S, stress corrosion, and blistering internally from hydrogen are of concern to linepipe steels of 50-80 and 40-60 kg/mm^2 respectively. City gas tanks of steel 50-80 kg/mm^2 tensile strength are subjected to Co-Co_2 mixtures, and stress corrosion may be a problem. Finally the area of sea water and pure water stress corrosion cracking is of interest with steels of tensile strength 110-140 kg/mm^2.

Although papers on the stress corrosion cracking of high strength steel in Co-Co_2 gas (Nippon Kokan Technical Report Overseas, Dec. 1974) and on the stress corrosion cracking of pipeline steel (Proc. 5th Int. Cong. on Metallic Corrosion, 493, NACE) were distributed, all discussion was avoided because of the sensitive nature of the subject matter. A manuscript on the stress corrosion cracking of high strength steel bolts by M. Tanimura and N. Seki was discussed quite freely, however. In essence, they have studied the effects of notch morphology on the value of K_{Iscc}. Various combinations of V-notch and slot plus a fatigue crack (to give a constant crack depth) were studied. The V-notches and slots serve to open up the crack toward the specimen surface. The findings were that crack growth rate above K_{Iscc} may be influenced, but that the value of K_{Iscc} is fairly constant.

Not very much was heard about welding but the Manager of the Welding Laboratoy, Dr. J. Tanaka did relate some implant test results generally. The implant test is a notch test designed to determine the strength of the heat affected zone of welds. It is a measure of the cold cracking susceptibility. Under stress and with time a threshold stress for cracking is determined which increases with temperature. The threshold stress may also increase with time, which probably reflects the egress of hydrogen. There was no opportunity to tour the facilities during the busy day. The overall impression is that this is a first-class technical group which is alert to the needs of the company and well aware of what is going on world-wide in related areas.

As a final comment, NKK notes that it enjoys a very low absenteeism rate (less than one percent) and relates this to the assurance by the company of job security, good pay and

opportunities for advancement. Does the high degree of paternalism weaken the employees resolve to work hard? On the contrary, says NKK, it heightens the resolve to do the best possible job. Comparing this situation with that in the United States, it is obvious that the big difference is job security. Perhaps in Japan the worker identifies with the company whereas in the United States company loyalty is less often given and received; the individual career is of first consideration. Of course, "high pay" and "opportunities for advancement" are subject to interpretation, and certainly, from outward appearance at least, the United States worker is better off materially. Still, the industrial success of the Japanese system gives pause.

FLUID MECHANICS AND RELATED RESEARCH ACTIVITIES IN KYUSHU

Leslie S. G. Kovasznay

Of the four main islands of Japan, Kyushu is the third in size and it is located in the southwest end of the group, closest to the Korean Peninsula. The name means "nine states" in Japanese and in ancient times nine indpendent lords ruled it. The island has strong characteristics that distinguish it from the main island (Honshu) both culturally and economically. The origin of Japan in both myth and archeology is strongly tied to Kyushu. Most recently, throughout the nearly 250 years of isolation, during the so-called Edo period (roughly 1610-1860), the only outside contacts with the West and China were through the port of Nagasaki. In addition there may have been some illegal contacts, mainly smuggling activities between Kyushu and nearby Korea. Furthermore, the distance of Kyushu from the de facto capital of Edo (present day Tokyo) located on the eastern end of Honshu is about 1500 km. This distance and the difficulty of the terrain certainly have attenuated the influence of the highly centralized government in Edo. In modern times, northern Kyushu became one of the highly industrialized areas of Japan, primarily due to the availability of coal. On the other hand, western Kyushu with Nagasaki as the important city became a center for ship building and related industries. Most recently, in the space age, it is important to note that all space launchings are made from Kyushu. Actually there are not one but two space centers. The original smaller one is operated by the University of Tokyo at Uchinoura and this operation is funded entirely by the Ministry of Education (Monbusho). Uchinoura is located on the rugged southern coast of Kyushu, west of Kagoshima-City. The newer and larger facility is that of the National Space Development Agency. It is located on the island of Tanegashima about 100 km south of Kagoshima City. The Tanegashima space center is financed from the Prime Minister's office with close cooperation of the Ministry of Post and Telecommunications as well as the Ministry of Transportation.

There are eminent centers of higher education in Kyushu, the most important being the University of Kyushu in Fukuoka. The Kyushu Institute of Technology is located in Kita-Kyushu, an industrial city within commuting distance of the Fukuoka-Hakata area. There are also strong research interests in fluid mechanics in the Nagasaki area, primarily at the so-called Nagasaki Technical Institute maintained by the Mitsubishi Heavy industries Ltd. I have visited all of these institutions and the overall impression was that the quality of work is high in these far provinces of Japan. Naturally, there is a certain amount of isolation and this is what all the scientists complained about. Nevertheless, most of the senior people do visit Tokyo many times during each year. The situation can be compared to France where the institutions located at a comparable distance from Paris are somewhat isolated but still keep sufficient contact with the capital. But let us look at the individual institutions.

THE UNIVERSITY OF KYUSHU

The University of Kyushu is a national university and it is located in Fukuoka on the north coast of Kyushu, relatively close to the point of contact with Honshu, the main island. There is both highway and railway communication from Honshu to Kyushu using undersea tunnels near Shimonoseki on the western tip of Honshu. Fukuoka and Hakata are twin cities served by a common transportation system. They have an international airport with about

8-10 daily flights to Tokyo and about half of those flights use jumbo jets. The demand is so large that practically all flights are full. In addition, the railroad station of Hakata is the western terminal point of the famous Shinkansen (super express or bullet train) system that brought the Hakata-Fukuoka area within only a seven hour train ride from Tokyo. (The distance is 1069 km or about 700 miles.) Trains are available more frequently than once an hour during the daytime, and the number of passengers carried daily from Kyushu to Tokyo is in the order of 100,000. Fukuoka is a city of about a million people; it is modern and busy in appearance and, as it was explained to me, it has never suffered from either earthquakes or floods, an important distinction for a city in Japan. The University of Kyushu was founded in 1911 as Kyushu Imperial University with only two faculties: Medicine and Engineering. After World War II it was reorganized and presently there are ten faculties with the corresponding ten divisions of the graduate school. These are literature, education, law, economics, science, medicine, dentistry, pharmaceutical sciences, engineering, and agriculture. In addition there are the following independent research institutes:

Institute of Balneotherapeutics (strongly influenced by the ample hot spring resources of Kyushu); Research Institute of Applied Mechanics, with the Sea Safety Laboratory; Research Institute of Industry and Labor; and Research Institute of Industrial Science (dealing mostly with problems of coal and energy) which includes the Kujyu Geothermy Laboratory.

The Research Institute for Applied Mechanics has five divisions: Fluid Research, Solid Mechanics, Sea Disaster, High Energy Mechanics, Ocean and Environment Research. In addition, there is the Tsuyuzaki Sea Safety Research Laboratory located off campus in Miyaji, about 25 km north of Fukuoka City. The objective of the Sea Safety Laboratory is to conduct experimental research in those branches of applied mechanics that are relevant to the safety of vessels, or to the effectiveness of breakwaters and other seaside and ocean structures during violent storms or large waves. To carry out such research activities there is a large experimental water tank, various testing machines for solid mechanics, as well as low speed wind tunnels. There is also a small air-water interface facility with associated measuring equipment.

The director of the Research Institute of Applied Mechanics is chosen by election from the senior professors and he serves for a three-year term. The present director, Professor Fukuzo Tasai, received me cordially at the Institute. Before he assumed the directorship, he was the chief of the Tsuyuzaki Sea Safety Research Laboratory and was mostly concerned with the sea-keeping quality of ships. The previous director who served two terms before Professor Tasai was better known to me from my previous contacts. He is Professor Jun-ichi Okabe, active in hydrodynamics research. The staff of the Institute consists of about 10-12 full professors with about the same number of associate professors and a smaller number of lecturers and assistants, a total academic staff in the order of 50. The total personnel of the Institute is about 100.

Probably the most fascinating work in fluid mechanics is being carried out by Professor Sadatoshi Taneda with his close collaborator, Associate Professor H. Honji. They published about 30 papers in the last five years both in Japan and abroad. Their principal approach is experimental and their main theme of research is unsteady flow around solid bodies, especially in those cases where vorticity and viscosity both play important roles. Professor Taneda extensively uses flow visualization techniques. These may involve either smoke tracers

in air or alternately dye tracer or hydrogen bubbles in water. Flash or stroboscopic lighting are both utilized, well synchronized with the periodic motion. Among the various configurations explored, wake vortices played a prominent role. When studying flows around rotating cylinders, the so-called "negative Magnus effect" was documented. Drag on oscillating cylinders, the flow around accelerating cylinders, were both explored in detail. The development of boundary layer instability was followed through with flow visualization. Vortex rings or their two dimensional equivalent, vortex pairs with equal and opposite circulation, were explored in a number of configurations. The propagation of gravity waves and the boundary layers created by them on the bottom were also studied. An impulsively started elliptic cylinder having a finite angle of incidence served to demonstrate the development of starting vortices behind airfoils and the dramatic influence of viscosity on all these phenomena was clearly shown. An interesting experiment was shown to me on the flow around a waving plate. In fact, the behavior of the periodic waving of a flag in the wind was studied by flow visualization. The behavior of tracer particles produced by electrolysis of water and utilized in flow visualization was also recently studied. During his long career Professor Taneda, in collaboration with Dr. Honji, has developed a "Kyushu school of fluid mechanics." They produced a number of graduates who adopted Taneda's careful techniques for trying to understand unsteady flows. Professor Taneda recently gave a summary of his work illustrated with very beautiful pictures at the 1976 IUTAM Congress in Delft, Holland (early September 1976).

Former director Professor Jun-ichi Okabe works mostly on theoretical fluid mechanics. Problems he has treated include water waves such as the determination of the exact shape of solitary waves of large amplitude. Problems concerning the role of friction on the bottom of a tidal basin, boundary layers developing on ship hulls, also were treated by him. In addition, Okabe developed a slender body theory for ships, and his last publication contains a new experimental approach to follow the swimming motion of a fish in waterways.

Leaving the Institute of Applied Mechanics, the Faculty of Engineering was visited. It has a total of 18 departments. Of all those, only one was visited, the Department of Aeronautics, as it has significant fluid mechanical interests.

In the Department of Aeronautics I called on Professor M. Iwasaki. His interest is in high Mach number flows. He has built a combustion driven shock tube tunnel reaching Mach numbers up to about seven and stagnation temperatures up to the order of 7,000°K. The working section is about 10 cm in diameter so only small models can be studied. Since at the high temperatures the working gas is ionized, the effect of an imposed magnetic field on the flow was obtained quantitatively. The effect studied is an increase of the shock stand-off distance, and it was determined as a function of the imposed magnetic field strength.

Professor M. Hayashi works on the other end of the Mach number scale, namely at low speed, essentially in incompressible flow. He is concerned with flow around blunt bodies when flow separation is important. These flows are being studied in configurations that suggest vehicles, buildings, bridges, or similar structures. Professor Hayashi systematically studied configurations of two or three bodies in tandem in order to determine the interaction between those bodies and optimum spacing for minimum influence. His results have shown that there are indeed possible savings on the drag of such structures.

KYUSHU INSTITUTE OF TECHNOLOGY (KYUSHU KODAI)

Located in the industrial city of Kita-Kyushu is Kyushu Institute of Technology (Kyushu Kodai), an institution dedicated to undergraduate engineering education. The Department of Mechanical Engineering admits about 80 undergraduate students each year for a four-year program and also about 15-16 graduate students for a two-year Master's degree program. Professor N. Jotaki with Associate Professor Y. Tomita are concentrating on the study of two-phase flows and their application to powder technology. In their case two-phase means solid-gas mixture where the solid particles are carried by air flow. The particular problems under investigation are the following:

a) Vertical transport;

This problem is mainly concerned with the pressure drop necessary to pump a powder-air mixture.

b) The performance of a blow-tank;

This is an important applied problem and the role of research is to explain the influence of design parameters.

c) Plug flow of solids in horizontal pipes;

The static and dynamic friction of the solid phase on the pipe walls controls the phenomenon, even qualitatively.

d) Pressure loss due to a sudden enlargement of a duct;

This is a common problem in powder technology and a number of configurations were explored.

In addition to the problems centered around powder technology, Dr. Tomita was working on an attempt to predict the effect of long chain molecule drag reducing additives in turbulent boundary layers using instability conderations. He has presented a paper on the subject at the Washington IUTAM Symposium on Drag Reducing Additives and Turbulent Structure (Reference:*ONR Tokyo Scientific Bulletin Vol. 1 No. 2).*

Professor T. Masuoka showed me heat transfer experiments using shadowgraph techniques, and Professor Y. Nishi demonstrated his experiment on flow in rotating cylinders. In the more applied area he also experiments with mixed flow pumping.

Kyshu Institute of Technology has a modest Master's degree program but it does not have a doctoral program at the moment; with continued improvement of the research posture of their faculty they hope to introduce it in the foreseeable future.

MITSUBISHI HEAVY INDUSTRIES LTD. - NAGASAKI TECHNICAL INSTITUTE

In Nagasaki city on the west coast of Kyushu, the Mitsubishi Company has a very large shipyard where some of the world's largest tankers were built. Visitors are always shown the two 1,000 ton capacity cranes so that by using both of them, 2,000 ton pieces can be lifted and placed accurately during ship building construction. The Mitsubishi Company also has a laboratory complex called Nagasaki Technical Institute that serves to carry out large scale industrial research for the company and in addition to do some research for outside customers.

Within the Nagasaki Technical Institute there are a total of 20 separate laboratories all located in the general Nagasaki area. Many of these are concerned with material sciences and in addition several of them deal with some very applied problems in industrial research, e.g., welding research laboratory, chemical research laboratory, computer application research laboratory, etc. Here we are concerned primarily with fluid mechanics so the main attraction is the aero-hydraulics research laboratory headed by an extremely dynamic person, Dr. N. Ukeguchi. He is a relatively young leader who oversees a group of highly trained research engineers.

At Mitsubishi, fluid mechanics has two major impact areas in the problems facing such a large industrial giant. First, pollution becomes an ever increasing problem when locating a plant in highly populated ares (that means practically everywhere in Japan), so the simulation of both the terrain and the overall turbulent diffusivity of the atmospheric boundary layer is imperative in any modern experiment. In order to carry out such an important program, there are both large and medium size wind tunnels. The largest wind tunnel has a working section with a 10 m x 3 m cross-section and a length of about 20 m. The group has developed techniques for the measurement of concentration of a simulated pollutant. In order to have a good "passive" contaminant, ammonia gas is used as a polluting agent because the measurement of its concentration is relatively easy. When modeling the plant site over a variable terrain the simulation of the vertical density gradient is not very practical, so instead of that quantity the turbulent diffusivities are simulated by using an internationally accepted table connecting the atmospheric lapse rate with the turbulent diffusivity observed. The proper variation of the diffusivity is achieved by placing variable solidity and variable mesh turbulence grids before the working section, and verification of the diffusivities so obtained is done by measuring the spreading of a simple plume. Since the procedure for such a simulation is well established, the services of the group are "marketed" by the Mitsubishi Company. Any company or agency can contract a study of their plant site and a measurement of pollutant concentration is performed on the topographical model of the new site. In addition to the experiments aimed at predicting pollution, additional wind tunnel experiments are being carried out studying wind induced vibrations in very large scale structures. A proper dynamic modeling (both in inertial and in elastic properties) requires the use of expensive models that are prepared on the premises in the attached workshops. There are a number of smaller wind tunnels and in fact many of the more basic type pollution experiments are carried out in those smaller wind tunnels. A good example of those has a working section only 2 m x 3 m in cross section and 10-20 m in length. As mentioned above ammonia gas is used as a contaminant. The concentration distribution contours of ammonia are obtained by using concentration with a semi-automated tracing.

Another important facility is the Nagasaki Experimental Tank. This is really not one but a pair of large towing tanks, one of them 165 m x 12.5 m and the other one 120 m x 6.1 m. Both are dedicated to ship model towing. An even more interesting facility is the Seakeeping and Manoeuvering Basin. There are two of those, one of them is 160 m x 30 m and other one 60 m x 60 m. These tanks are equipped with two groups of wave-makers. One set is installed along two adjacent sides and thus creates waves simulating rough sea for the ship models. In the maneuvering basins tests on free models are carried out by means of radio control of the rudder position and the R.P.M. of the propeller. The models can be rapidly accelerated by a towing carriage if such a mode of operation is necessary. The position of the model is located by an acoustic position detecting system and is plotted automatically by a digital computer. With the use of these new basins the accurate evaluation of wave form and extensive study of ship's motion can be made in order to meet the demand for optimization of navigation safety. These facilities were completed as recently as 1972 and they are rather modern facilities unique in the whole Pacific area.

TANEGASHIMA SPACE CENTER

The Japanese Space program is modest in its goals when compared with the U.S. or the U.S.S.R., but the aim is to obtain experience in the high quality technology connected with space research. They appear to aim less at achieving high prestige "space spectaculars," but rather more at developing competence in the relevant technology. Technical descriptions of the Japanese space effort are readily available in the U.S. due to the close cooperation between NASA and the Japanese Space Development Agency. Consequently the purpose of the present discussion is rather to give the impressions of someone who is not a space technology specialist but an academic type fluid mechanics research man. In 1966 I visited the University of Tokyo Space Center in Uchinoura and witnessed the launching of small weather rockets so this time it did not appear to be important to revisit that site. Instead I made a small detour to the newer and larger Tanegashima Center. Tanegashima is an island about 40 km long and 10 km wide. Its only airport is about 100 km from the Kagoshima International Airport. There are several daily flights from Kagoshima using only small aircraft. Although the climate of Tanegashima is good, it is not an important resort area in contrast with its close neighbor Yakushima, mainly because the latter has high mountains and 1000-year old cedar (Japanese Sugi) trees. The farmers of Tanegashima engage in semi-tropical agriculture. It is one of the few areas in Japan where sugar cane is cultivated as a regular commercial crop. Due to the mild climate, rice can be harvested twice a year. At Tanegashima Airport, when looking at the tourist brochures available for the Japanese travelling public, one notices that the principal tourist attraction of the island is a bus tour of the Space Center's facilities.

Curiously enough the space activities are limited to two short "open seasons" each year. One is around August-September, the other around late January and February. The reason for this curious schedule is a long argued truce between the Space Agency and the fisherman's union. The two periods when launching is permitted were agreed upon as a compromise between a total ban requested by the fishermen picketing the nearby ocean with their fishing craft and the government which had no reasonable alternate site available for launching. As a result there is a long "off-season" most of the year when there are only a few hundred employees on the island occupying themselves with maintenance of the facilities and with some ground testing of rocketry. On the other hand during the "open-season" the permanent

crew acts as host and coordinator to the contractor's personnel who are assembling and operating the equipment brought in from the industrial areas on Honshu. The various facilities were shown to me by Dr. H. Sakaki, Director of the Tanegashima Center. Besides the actual launching sites (Osaki Launch Site and Takesaki Launch Site) there are a number of telemetering and tracking stations scattered around the island as far as 20-30 km from each other. The Nogi Radar Station is in the northern part of the island while Uchugaoka (literally Space Hill in Japanese) Radar Station is in the south as are a few more minor sites.

The southern tip of the island is famous for an earlier technological feat in the 16th century (1543 is the presumed date). A Portuguese ship was washed ashore near the southern tip of the island. The Portuguese spent several months repairing their ship. They befriended the local people who admired their marvelous weapon, firearms. The local Daimyo (feudal lord of the island) bought two of the guns at a very steep price and then ordered the village blacksmith to duplicate them. When the blacksmith began to encounter technological difficulties (the lock mechanism was difficult to duplicate) he approached the Portuguese who appeared to be the most knowledgeable of the crew and offered him his own daughter in return for the technology. The Portuguese expert gladly accepted and according to the local tradition the girl sailed away with the Portuguese when their reconditioned ship became again seaworthy after a few months of repair. After that for some time, the Japanese called firearms by the name of "Tanegashima teppo" (the word "teppo" implies iron wrapped around). The event is recorded on the stone monument at the southern tip of the island and I could not help but pause for a moment and think about the intricacies of "technology transfer," a current term much heard around the world and the simple solution they found in Tanegashima.

FLUID MECHANICS IN BANGALORE, INDIA

Leslie S. G. Kovasznay

Bangalore, one of the most attractive cities in India, is located in the tropics at northern latitude 12°. It is inland on the Deccan Plateau at approximately 3,000 feet altitude so it has a healthy, pleasant climate. Bangalore was also fortunate with its urban development. The city is located in the former Mysore State which presently, with some changes in its territorial boundary, became the State of Karnataka and in fact Bangalore is the state capital. The area is fortunate in many ways: first the Maharaja of Mysore was often a liberal and enlightened ruler; furthermore the southern portion of the state where Bangalore is located had a long tradition of irrigation projects even before the British rule so it was and still is a relatively prosperous area of India. During the British rule, it was the home of a large military garrison, so it had a certain measure of order and prosperity; also, because of its pleasant climate, many British officers retired in Bangalore. In recent times, a large number of research activities, both government and private (e.g., the S.K.F. Drug Company's research laboratory), is located in the area. The city has wide streets, nice residential areas, so it became one of the most attractive places to live in India.

In Bangalore, there are two major and several minor institutions which all have some research program in the general area of fluid mechanics or in one of its engineering applications. The two major institutions are the Indian Institute of Science and the National Aeronautical Laboratory. In addition, there is fluid mechanics interest at the Hindustan Aircraft Company and also at ISRO (Indian Space Research Organization), both located in Greater Bangalore.

INDIAN INSTITUTE OF SCIENCE

According to the opinion of many scientists visiting India, the Indian Institute of Science is the most prestigious academic institution in the entire country. The history of its development is rather interesting. It was founded by the endowment of a prominent member of the TATA family (they are often referred to as the Rockefellers of India). Jamsetji Nusserwanji Tata was a parsee* from the city of Bombay, a man of not only great wealth, but also of great vision. On September 18, 1898, he decided to commit a significant portion of his fortune to an endowment fund to establish a research institute for science. He died in 1904 but long before that he set up the proper mechanism to launch the future institute. It became a three-way partnership: the Tata family gave the funds, the Maharaja of Mysore gave an attractive land site (372 acres in Bangalore city), and the Government of India passed special legislation to create the appropriate status for the new institution. The Institute began

* The parsee is a small ethnic and religious minority of Persian origin. Often they are men of great wealth and culture. They marry only within their own group and do not welcome converts. There are about 80,000 and about 80 percent of them live in the city of Bombay. They are best known for their unusual custom concerning their dead. The "towers of silence" are well known to the visitors of Bombay. These are circular towers with an inverted cone-shaped interior somewhat like an amphitheater. Unseen from the outside the dead are deposited there to be devoured by the waiting vultures until only the clean bones remain.

functioning in 1911 with two departments only; one was general and applied chemistry and the other electrical technology. During the subsequent two-thirds of a century, the Institute grew to an impressive size. In recent time, it receives significant contributions from the Indian National Government so it has reached the point where the annual operating budget, exclusive of capital expenditures is in the order of 25 million Rs. (about three million U. S. dollars). The amount is quite significant especially if the large difference between Indian academic salaries and those in the United States is taken into account. In India they amount to about the same number of rupees as dollars in the United States; during my visit, the rate of exchange was $1.00 = Rs.8.75, which shows the difference to be almost nine to one.

Presently there are 20 departments in the Institute with a total student enrollment of over 600 and with a total research staff of about 380. These also include about 100 professors. The Indian Institute of Science is a university in the legal sense, but it is primarily a graduate school and a research institution, although three of its departments do offer undergraduate programs because of the urgent need in India. Looking at the quality of the staff, one is impressed by the very large portion of the members who have obtained advanced degrees abroad, many among them at the most prestigious universitites in the U. S. and Europe. The strongly international flavor is further enhanced by the large numbers of foreign visitors, both of short and long term. The Institute provides accommodations for the visitors in an attractive guest house that serves also as a kind of faculty club. During my one week stay there, I met many important foreign visiting scientists. The Institute leans heavily toward the physical sciences and engineering although the biological sciences are increasingly represented. In many ways it has a strong resemblance to the California Institute of Technology in Pasadena. This is no accident since the present director, Professor Satish Dhawan, is a Cal. Tech. Ph.D. Also a number of the faculty in the Aeronautical Engineering Department received graduate degrees at Cal. Tech. It should be mentioned that Professor Dhawan is not only the Director of the Indian Institute of Science but also has a cabinet post in the Indian Government; he is Secretary for Space reporting directly to the Prime Minister. Although Dr. Dhawan comes from the north, he is well liked and respected in southern India where most of the space program activities are concentrated.

The Department of Aeronautical Engineering has as chairman Professor T. N. Krishnaswamy. He is mainly concerned with operating the large scale low speed wind tunnel used primarily for aerodynamical testing. My principal contact in the department was Professor R. Narasimha who arranged all my visits in the Bangalore area. Professor Narasimha's background was originally in the area of rarified gases (he has recieved his Ph.D. at Cal. Tech. working with Professor H. W. Liepmann), but in later years he became quite interested in low speed fluid mechanics especially in turbulence.

Professor R. Narasimha gave me a quick tour of the Department's facilities. The largest facility is a 9' x 14' open circuit wind tunnel which is dedicated mostly to aerodynamic testing and Professor T. N. Krishnaswamy directs that work. For research in more basic fluid mechanics a 7' x 5' cross section closed return wind tunnel is used. The turbulence level is much lower than that of the open tunnel and basic experiments can be performed. In decreasing order of size there is a 20" x 20" cross section low turbulence wind tunnel and finally there are several 12" x 12" cross section channels available for work on boundary layers, wakes and similar problems. From early times, there remained a 15' diameter vertical wind tunnel built for airplane spin tests. The future use of it is being reconsidered now for

some more basic research oriented project. In the compressible flow range there are intermittent (blow down) supersonic wind tunnels. The larger one has a 7" x 5" and the smaller one a 3" x 1" working section, and the compressed air storage tanks can be also used to operate other facilities such as induced flow tunnels in order to cover the entire high subsonic, transonic and supersonic range of Mach numbers up to about M = 4. For tests at even higher Mach numbers there is a 2" diameter shock tube and 12" hypersonic shock tunnel. In addition, there is under construction a 6½" diameter 17' long shock tube and a 8" diameter hypersonic wind tunnel. After looking over the research problems currently under study, it is clear that the interest is concentrated at the ends of the Mach number scale, first at low speed flows where turbulence is an important feature, then at supersonic and hypersonic flows where highly compressible flow and real gas effects are prominent. During the long history of the Institute in the Department of Aeronautics considerable experience was gained in wind tunnel design and instrumentation, as well as in testing of aircraft models and components. In addition to those recently some non-aeronautical projects have been considered too.

The facilities and experience of the group were and still are utilized by a number of outside agencies, such as the Hindustan Aeronautics Co., the National Aeronautical Laboratory, Ministry of Defense, and Vikram Sarabhai Space Center. The basic fluid mechnics problems of present interest are as follows: transition from laminar to turbulent flow as well as the reverse transition (relaminarisation) occurring in case of rapidly accelerated boundary layers. Other projects are flow development in axisymetric and three dimensional boundary layers, the development of wakes, wall jets, separation bubbles, base flow behind blunt bodies, and the investigation of possible methods for the suppression of flow separation phenomena. Analytical work that is being carried out is strongly motivated by the desire to obtain practical results in calculating aerodynamic properties or in predicting aeroelastic bahavior like flutter and instability. On the other end of the Mach number scale, research in real gas flows includes rarified gas phenomena such as is encountered by satellite vehicles and some more basic problems, such as the details of the shock structure including dissociation and ionization effects. Industrial aerodynamics is becoming increasingly important and model experiments are being carried out on wind pressure developing on tall chimneys, suspension bridges, and on high buildings in general. There is a combustion laboratory where flame propagation, ignition and extinction are studied as well as the properties of different propellants. Those problems are motivated by interest in space applications. There is a certain amount of research, or rather development on problems that are not related to aeronautics at all, such as optimum design of windmills for rural application.

On the other end of the scale, Professor Narasimha in cooporation with Dr. P. R. Viswanath is engaged in a group of problems involving base flows at supersonic Mach numbers. The practical interest is in the design of appropriate "boattail" configurations to reduce the base pressure. The basic interest is the attendant reverse transition in the expansion flow at the corner. The analogue problem translated into low speed flows involves such problems as the backward facing step as well as the rapid distortion of turbulence by the mean gradients.

Professor Badri Narayan was well known to me from his work on turbulent boundary layers expecially concerning the turbulent bursts occurring just outside the viscous sublayer. He made a significant contribution a few years ago when he concluded that the bursting rate

does not scale with the wall parameters but rather with the so-called "outer" parameters, such as the total boundary layer thickness and the free stream velocity. His continuing interest in turbulence is evidenced by his recent work on low speed flow problems such as the flow past a step. In addition he is studying wall jets and similar shear flow structures. A major instrumentation development is underway. Of course the hot-wire anemometer was used extensively for some time, hot-wire equipment was locally developed and the local instrumentation expert is Dr. A. Prabhu.

Development of LDV (Laser Doppler Velocimeter) is under way, but so far no significant results have been obtained with the use of LDV. There are advanced and rather detailed plans for digital processing of the data in turbulence measurements, although at the moment mainly anologue methods are used. In order to complement the experiments, there is a corresponding theoretical effort in the group. In order to size up the total effort in research, we must look at the papers published by the group. The list is quite large and it includes papers published in foreign journals and some of them appeared in the most demanding quality journals. One thing particularly impressed me in the group, and this is their intensive involvement with other fluid mechanics groups in India. There is a continuing cooperation between colleagues at IISc and NAL. There is a great deal of activity with other academic institutions too. They take the form of special courses, workshops, etc. They have a very active program for the enrichment of research experience for college teachers from other institutions where research opportunities are limited or even non-existent. My general impression is that the staff of the Indian Institute of Science is very active both in basic research but also they serve as an elite, for the whole of India. (*I am using the word* advisedly in an age when it is often used more for condemnation than for praise.)

THE NATIONAL AERONAUTICAL LABORATORY

The National Aeronautical Laboratory was organized soon after the Indian independence and it was located in Bangalore, a choice probably influenced by the existence of a strong active group at the Indian Institute of Science, who certainly helped to launch this more applied oriented laboratory. The present director is Dr. S. R. Valluri (also a Cal. Tech. Ph.D.) whose personal research interest was in solid mechanics and material sciences before he assumed his present administrative responsibility. NAL has seven scientific divisions and in addition there are other minor activities. There is a pilot plant, an information center, and a number of collaborative programs with other organizations. The total staff is about 1200, of which about 250 are scientific staff and another 130 are administrators. The largest group is the Aerodynamic Division which also includes fluid mechnics. The Aerodynamic Division has a staff of about 200 with 57 scientists among them. The head of Aerodynamics is Dr. M. A. Ramaswamy whom I met briefly. My prinicpal contact and guide was their prominent fluid mechanicist, Dr. K. S. Yajnik. A large amount of my time was spent with him in his boundary layer laboratory, where a specially built boundary layer tunnel is in the process of being calibrated and the research work proper is just about to begin. The boundary layer tunnel is a long duct with a 10" x 20" cross-section. There are provisions for controlling the pressure gradient and special care was taken to obtain a uniform flow field. Preliminary calibration has shown that the mean velocity is within 0.5% of the mean value across the section and when two screens are placed in the settling chamber the free stream turbulence level is less than 0.08%. Mean velocity and turbulent velocity fluctuations were measured at different stations in order to determine any initial non-equilibrium effect. Skin friction was measured

by Preston tube and it agrees within 2% of that obtained by Bradshaw's method. In order to fix transition two turbulence trips were used and the turbulence intensity profiles were compared with those from other standard data. The velocity distribution was plotted in wall coordinates and they were compared with the "law of the wall."

Because of the demand for more sophisticated instrumentation various development projects are being carried out in or in connection with the boundary layer tunnel. Preliminary work is in progress where a pilot model Laser Doppler Velocimeter (LDV) and hot-wire instrumentation will be used extensively. After visiting the boundary layer tunnel, other facilities were inspected. There are two large and one small blow-down tunnels; they call them "trisonic" wind tunnels. The word "trisonic" means that it is subsonic, transonic and supersonic all in one piece of equipment. The larger has 4' x 4' square cross section and the smaller one has a 1' x 1' square cross section. The available testing time depends of course on the Mach number but a sufficiently long testing time can be achieved in order to change the Mach number and model position during operation. The transsonic sections are perforated for variable Mach numbers. The supersonic sections have various nozzle blocks for different Mach numbers. The tunnel is in almost constant use, limited only by the availability of electric power. It is the chief source of aerodynamic test data in India. The tunnel also serves to test various configurations for ISRO (Indian Space Research Organization), for the national defense, and for the aircraft industry. Many of the models are mounted on one of the side walls and internal strain gage balances are used. The models include some for aero elasticity tests and some other complicated configurations. The aerodynamic Division also has projects that are aimed at serving the Indian rural economy (similar projects were also seen at the Indian Institute of Science). One logical development project is to design windmills for rural use, some for electric power, but most for pumping water. Vertical shaft Savonius type runners were tested and easy-to-construct configurations are being developed. When I asked how would they provide cheap storage tanks for the water pumped the surprising answer was that in and near Bangalore on the Deccan Plateau granite is a very common stone, and water tanks made from granite slabs are relatively easy to fabricate. To my amazement, I was told that until relatively recent times, even utility poles were often made of granite. On the other hand metal parts are very expensive in India and are to be avoided if possible.

The overall impression of my brief visit to NAL was quite favorable; the staff appears to be alert, active and they attempt to bridge the gap between the basic sciences and the demands of industry and government.

If one further enlarges the view to include all Bangalore establishments, one is surprised to find how many highly trained and competent people are in such a small geographical area. Since there are sufficient numbers of like-minded scientists and engineers working in similar fields, they can maintain the mutual intellectual stimulation and also they mutually uphold the quality requirements. (I did not wish to use the cliche "critical mass.") Nowhere else in India have I seen a comparable level of competence and enthusiasm as I found it in Bangalore.

MICROBIOLOGY AND MARINE SCIENCE AT KAGOSHIMA UNIVERSITY

Roy M. Johnson

Located at almost the southern end of Kyushu, Japan, on Kinko bay, across from the active volcano of Sakurajima is the faculty of Fisheries of Kagoshima University. Housed in several three story concrete buildings on its own campus of some 58,000 square meters, the fisheries faculty currently has 17 authorized chairs. Professor Hara is Dean of the faculty. He will retire in 1977 and his successor will most probably be one of the ten current professors. Fisheries offers a Master's program but expansion toward offering the doctorate as well as adding new buildings is in progress.

Professor Daiichi Kakimoto now heads the microbiology group and is presently studying the ecological role of pigmented bacteria in marine waters with some emphasis on purple pigmented species. He also with Dr. Taizo Sakata is continuing work on protein enzymes of marine bacteria. Associate Professor Tomio Hidaka heads the marine bacteriophage studies and spent three weeks in the Southern Pacific last fall attempting the isolation of marine phage.

Dr. Hidaka along with Dr. Taizo Sakata from Dr. Kakimoto's laboratory was among 16 University of Kagoshima scientists using the University's second largest ship, the Keiten-maru, for the fall cruise in the Guam area. The Keiten-maru, approximately 884 tons and 40 meters long, took its maiden cruise to Los Angeles in 1975. The University also has the two year old Nansei-maru some 19 meters long and 70 tons and the older Kagoshima-maru which is 1038 tons and 60.5 meters long. All three ships are used on a regular rotating basis for the training of students in all aspects of fisheries.

Professor Teruhisa Katayama heads the biochemistry group and is currently involved in the isolation and identification of steroids associated with marine production and quality. Associate Professor Muneo Sameshima is studying the amino acid nutritional requirements of shrimp.

Associate Professor Akio Kanazawa heads the organic chemistry group studying the chemistry of sterols from marine sources.

The facilities available to the fisheries group are enhanced by an informal relationship with the medical faculty housed on a separate campus with completed basic sciences and clinical research buildings just two years old. Professor Hirano heads a group at the medical school studying various aspects of anaerobic bacteria. The doctorate in microbiology is offered by the medical school faculty.

On the main University campus Associate Professor Shiro Higashi teaches general bacteriology and molecular biology. His research has involved the invasive mechanism of *Rhizobium* species and he is currently studying the preservative (antimicrobial) activities of several plant extracts.

The entire attitude of the microbial and marine science faculty at the University is one of optimism and growth which appears to be supported by the establishment of new advanced degree programs and physical facilities. The senior administrative officer, President M. Kanie is a former agricultural bacteriologist with research interest in fermentation studies.

A list of recent publications follows: –

Recent Publications
Faculty of Fisheries Kagoshima University

Sakata, T., S. Suami and D. Kakimoto 1975. Factors affecting the germination of *Bacillus subtilis* spores. Mem. Fac. Fish., Kagoshima Univ. *24*: 139-147

Sashihara, N., T. Sakata and D. Kakimoto 1975. Study on the proteases of marine bacteria. Mem. Fac. Fish., Kagoshima Univ. *24*: 149-160.

Tsuda, Y., T. Sakata and D. Kakimoto 1974. Study on the esterase isozymes of marine isolates belonging to *Vibrio* and *Pseudomonas*. Mem. Fac. Fish., Kagoshima Univ. *23*: 123-135.

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TETRAPODS, IGLOOS, AND THE COAST OF JAPAN

H. J. Walker

INTRODUCTION

Japan, with an area three times that of Louisiana and virtually the same as Montana, has a coastline that is 31,382 km long. This length provides a value of one km for each 14 km^2 of area, which is exceptionally favorable. Nonetheless, population density is so great (275/km^2) that each kilometer of coastline is shared by nearly 4,000 people, i.e., each person has a total of 25.5 cm (or 10 inches) of shore. Thus, if all of the people of Japan lined up side by side they could form a double wall around all of Japan.

Such a lineup would be very difficult, of course, because the coast of Japan is highly varied. In many places hills and mountains rise directly out of the sea. Peninsulas and small islands such as in the cultured-pearl area of the Shima Peninsula are numerous. Some coasts are volcanic; others are earthquake prone and extensive earthquake-generated landslides are not uncommon. There are other coasts however, which are low; some have long beaches, others have sand bars and/or sand dunes, and still others have abrasion platforms. Coral reefs occur in the south and lagoons are common along many coasts. Some lagoons, such as Hachirogata in northern Honshu (Fig. 1), have been reclaimed. Formerly Hachirogata lagoon was the second largest body of water in Japan, but during the 1960's much of it was filled in order to increase the country's rice production.

Marine generated coastal processes are equally as varied. They include erosion by ice on the shore of the Sea of Ohkotsk in Hokkaido, by monsoon generated waves on the coast of the Sea of Japan, and by typhoon and tsunami generated waves along much of the Pacific shoreline. Although exposed coasts are lengthy and bear the brunt of waves which frequently have an extremely long fetch, there are many relatively protected lagoon, bay, and sea (as in the Inland Sea) coasts.

The fact that the coasts of Japan are important in the lives of the Japanese people is well known. Coastal fishing has been traditional and prosperous and fishing villages dot the coast. Coastal catches, however, have recently decreased—partly because of local overfishing and partly because many fish are now being caught in deep waters before they reach the coast. Another important factor is the increase in pollution of coastal waters. Pollution has progressed to such an extent that the cultured-pearl industry is suffering. Nonetheless, the coastline and its numerous bays and harbors is still important for its abundant biotic resources. Further, increasing attention is being given the development of aquaculture—a lagoonal and coastal enterprise.

In addition, Japan is one of the world's leading industrial nations. However, it differs from most of the rest of the industrial nations in that its industry is based almost entirely upon imported raw materials. These materials, once converted into manufactured goods, are exported. Most large industrial complexes are located in the lowland along coasts and especially along coasts on the country's Pacific side where the best harbors are found.

The physical nature of the land, a fishing heritage, and an industrial emphasis have combined with other factors to attract great concentrations of people to coastal areas. Today, some 80% of the over 100 million population of Japan are so located.

COASTAL RESPONSIBILITY

Of the 31,382 km coastline, it has been calculated that 15,020 km or 47.9% needs protection of some kind (Fig. 2) and that 10% suffers from severe erosion (Fig. 1). This 15,020 km is under the control of three Ministeries although in actuality only 12, 327 km have been officially assigned (Fig. 2). A little over half (8,080 km) has some protection at present, i.e., one quarter of the coastline of Japan has been modified to some extent by man.

The three Ministeries that control the protection efforts along the coast of Japan are those of Construction, Agriculture and Forestry, and Tranportation (Fig. 3). Each has responsibility for lengthy shores with the longest belonging to the Construction Ministry. Nearly half of the shoreline needing but not yet protected, is under its jurisdiction.

In recent years the increase in monies for coastal protection has been rapid. In 15 years the amount has increased eight times from 9.1 billion yen in 1961 to 76.1 billion in 1976 (Fig. 4), i.e., a value of about $260 million.

CLIFF COASTS

Although cliff coasts are common in Japan, only recently have they begun to attract scientific attention, an attention that has resulted from the construction of scenic highways and atomic power stations. Indeed, some of the erosion-prone cliffs, especially those adjacent to railroads and highways, are now protected by artificial coverings. Prior to such aesthetic and energy related interest, the severe erosion that occurs along cliff coasts was of little concern. Erosion rates along many cliff coasts range to over 2 m/year with rates depending mainly on rock strength and wave energy. Whereas the beaches along sandy coasts can be restored by artificial nourishment with some success, cliffs, once eroded, are gone and can hardly be returned to their original state.

SUBSIDENCE

Subsidence began to receive serious attention only recently in Japan, just as in the United States. In Japan it had become an important problem before World War II because of the rapid advance of Japan's industry after World War I. Overpumping the ground water and/or natural gas, especially that associated with the industrial areas in Osaka, Tokyo, Nagoya, and Niigata, resulted in much subsidence. In all of these cities there are now large areas of land below the "zero-meter line" (as the Japanese refer to their non-marine land presently situated below sea level). The areas involved are sizable, the largest in Nagoya where over 200 km^2 are below sea level. The rate of expansion of subsided areas has also been rapid; e.g., in Tokyo the zero-meter region increased from 35.2 km^2 in 1960 to 61.5 km^2 by 1970.

Osaka provides an interesting and informative example of change in subsidence rates with changing conditions. One hundred years ago the coastal part of Osaka was used for rice

cultivation. Between WWI and WWII much of this area was converted into a massive industrial complex. Ground water was pumped in great quantities and subsidence followed. During WWII, however, the factories were destroyed, ground water consumption decreased, and subsidence ceased. After the war, industrial development was reinitiated, ground water consumption again increased, and subsidence began anew. This condition continued until the 1960's when laws were enacted restricting groundwater usage resulting in stabilization of the land surface.

Subsidence aggravated disasters in the past in many locations in Japan. A typhoon in 1959 was responsible for heavy flooding in Nagoya, flooding which killed more than 5000 people. Much of this disaster occurred in the zero-meter region. In Niigata, it was a severe earthquake in 1961 that brought about flooding in the subsided area. These two disasters led to the construction of seawalls not only in Nagoya and Niigata but also in Tokyo, Osaka, and other areas where subsidence has been severe.

SEA WALLS

In all coastal areas where subsidence has been severe lengthy seawalls have been constructed. Indeed, the retaining wall—of which the seawall is a marine version—is one of the most conspicuous and widespread artifical forms to be seen near water in Japan. Artificial levees, for example, border most rivers whereas seawalls are found along many low-lying coasts. Some seawalls are very old and many display several stages in their development. Heightening and widening seawalls along some coasts appears to be an almost continuous effort. Along some shorelines, expecially those where typhoon waves are likely to be accentuated, seawalls are more than 15 m high. At other locations seawalls merge with river mouth retaining walls and at these locations serve the double purpose of preventing encroachment of the sea and controlling river flow.

GROINS AND DETACHED BREAKWATERS

From the standpoint of loss of life and property the retaining wall is undoubtedly the most important of the man-made coastal modifications. Nonetheless, great amounts of money, time, and scientific effort have been expended in attempting to control beach erosion oftentimes in concert with the development of retaining walls.

Sand removal from coasts is a natural process, and has been since the still-stand of sea level was reached some 5,000+ years ago. However, it has become aggravated along many coasts of the world because of a variety of human activities—especially those activities related to altering the discharged sediment load of rivers through the construction of dams and river linings. Along the Niigata coast, for example, shoreline sand starvation, because of modifications of the Shinano River, has been so great that the beach has receded more than 300 m during the past 50 years.

The groin has been the structure most commonly used to prevent coastal beach loss and to trap sand fromerly lost due to longshore drift. Groins have not always been successful and other methods such as detached breakwaters have recently been introduced instead.

The experiences at Kaike Beach in southern Honshu is an excellent example of man's effort in Japan to not only stop beach erosion but to re-establish eroded beaches. Kaike Beach faces the Sea of Japan which is notorious for its rough seas during the winter monsoon season. This beach has long suffered from severe erosion and local peoples, using pine logs and sand bags, were unsuccessful in their attempts to control it. Between 1946 and 1956 groins were constructed along the beach and although the beach was initially reestablished slight changes in wave regimes and unrepaired wave-damaged groins again led to loss of the beach by the early 1960's.

The next attempt at Kaike was the construction of 3 detached breakwaters 150 m offshore. The dissipated wave energy not only reduced the erosive nature of the waves but also brought about the formation of tombolos between the shore and the breakwaters reestablishing the beach.

Additional benefits have accrued from the use of detached breakwaters as exampled at Ishizaki, a fishing village on the south coast of Hokkaido. In 1960-61 seawalls were built at the back of the beach. The sand in front of these seawalls was stripped from the bedrock eliminating the beach. Plans at first called for groin construction but it was decided to use detached breakwaters instead. In all 12 of these structures were built and all served the purpose of re-establishing the beach in the form of tombolos, an additional benefit accrued. Because of the nature of these breakwaters, the sand on the bottom seaward of the structures was transferred to their innersides. This transfer exposed the rocky sea bed in front of the breakwaters, a surface upon which an important type of seaweed grows well. Because this seaweed is a desirable food item, its presence serves as an additional and now a very important source of income to local fishermen and their village. The role of the detached breakwater in Japan has been documented in a 20 minute, color motion picture entitled "The Detached Breakwater System." It was produced by the Ministry of Construction under the supervision of Osamu Toyoshima.

TETRAPODS

Although seawalls are usually solid concrete they sometimes are buttressed by other materials, frequently tetrapods. Tetrapods have been used in Japan for over 20 years. One of the first structures made from them was an offshore breakwater at Niigata. Taking several years to construct, it required nearly 90,000 tetrapods before completion. Most of these tetrapods (being among the first made) weighed only 4 tons. Today they come in many sizes; the largest now being used weigh 50 tons.

One of the most common uses of tetrapods is for breakwaters in connection with harbors as at the ports of Abashari and Rumoi in Hokkaido, and Kuji, Sandai, Fukushima (in connection with a nuclear power plant), and Akita in Honshu. Most structures use a variety of sizes, e.g., the breakwater constructed for the Tokyo Electric Power Co., Ltd. at Fukushima took 5 years (1966-1970) to complete and required 820 - 8 ton, 3,482 - 10 ton, and 5,827 - 25 ton tetrapods.

These strucutres are very expensive. I was told that to construct a breakwater using 50-ton tetrapods costs up to 3,000,000 yen per running meter, i.e., about $10,000,000 per kilometer.

The tetrapod is patented by the Nippon Tetrapod co. Ltd., headquartered in Tokyo. It and other companies have developed a variety of forms since WW II. Many coastal sections have several types present and represent either different models used by the same company or models from different companies.

Today, prior to the actual construction of most systems, model tests are conducted. The Nippon Tetrapod Co., for example, has a large modern, well equipped laboratory near Tsukuba, the new research center for Japan about 40 miles north of Tokyo.

IGLOOS

An additional function of this laboratory is the development of new models for use in shore defense systems. Better coastal defense and lower cost of construction and maintenance are major objectives in this research. An additional reason, and one that is increasing in importance as social attitudes change in Japan, is the increasing demand for an aesthetically pleasing design—the need to decrease visual pollution.

One of the most recent developments is the "Igloo." It is a wave dissipating structure which can serve as a retaining wall and even a wharf. The structure is made of a series of concrete components (Fig. 5) which are produced in 6 standard sizes varying in weight from 20 to 40 tons. When the individual components are combined, a wall is formed which is composed of a series of vertically interconnected circular chambers. As a wave strikes the vertical front its water is separated into layers by the horizontal plates which join the tiers of the igloos together. Each layer of water is separated by the vertical rounded pillars into water jets. Each jet flow is divided into counter rotating whirlpools within the chamber and with a loss of energy because of friction. The connection between the tiers of igloos permits vertical flow resulting in turbulence and further loss of energy. The water descends through these connections to discharge seaward into the following wave trough.

Construction of this type of wave dissipating wall was begun at 4 different locations in Japan (Fig. 1) during 1975. When completed these 4 walls will be 950 m in combined length. The prospects for the construction of other structures of this type are excellent. The igloo's major asset is the obvious one of energy reduction—however, another benefit is that it meets the recent demand in Japan that man-made structures also "be in harmony with nature and the environment."

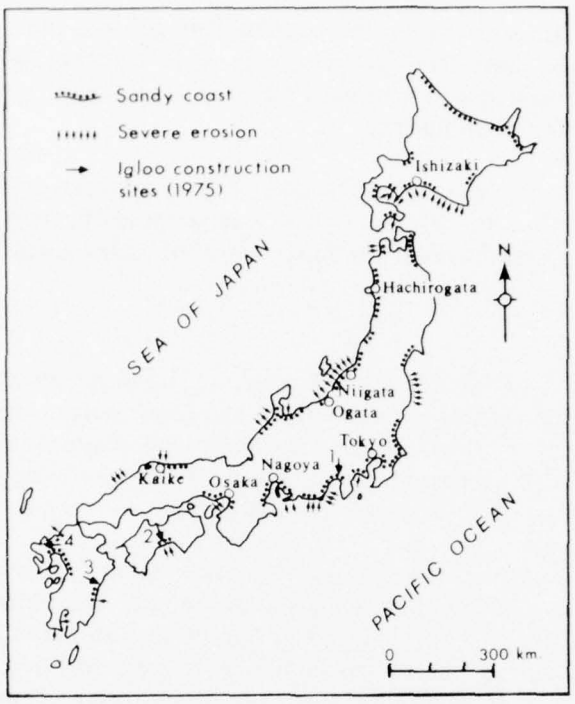

Figure 1. Japan and coastal characteristics. Locations at which Igloos are under construction are: 1. Namazu, 2. Kochi, 3. Hosojima, and 4. Karatsu.

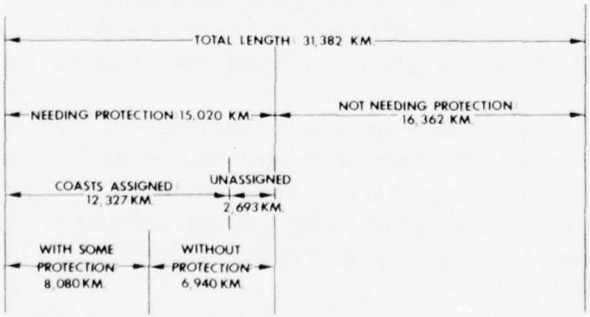

Figure 2. Coastal protection characteristics.

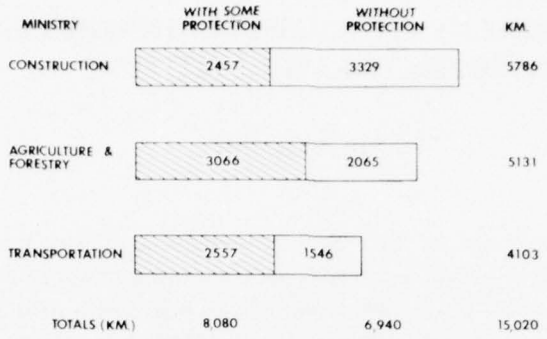

Figure 3. Ministries and coastal responsibilities.

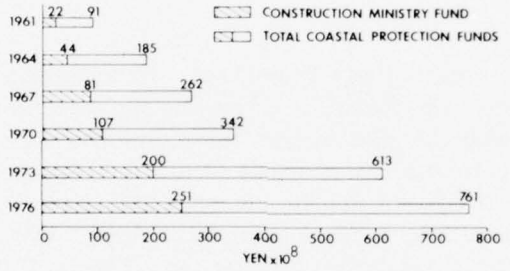

Figure 4. Government funds allocated for coastal protection.

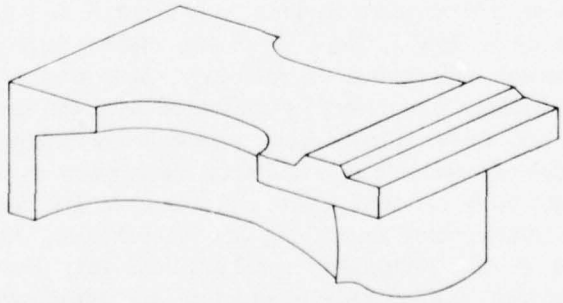

Figure 5. Perspective drawing of an Igloo component.

OPERATION CHERRY BLOSSOM WINNERS VISIT MITSUBISHI—KASEI INSTITUTE

Morton A. Bertin

The Mitsubishi-Kasei Institute of Life Sciences might attract a reasonable amount of attention in the United States, but it is a rarity, indeed an anomaly, in Japan. Established in 1971 by the Mitsubishi Chemical Industries, it is dedicated to the pursuit of basic research in the life sciences. Unlike the United States, where government is a very heavy supporter of industrial and other research, in Japan over 70 percent of the research funds comes from industry and of this less than seven percent is allocated for basic research. The Institute claims to have no responsibility to the mother industry in its programing, the key obligation being the pursuit of good science. This research center had been selected as one of the two places to be visited by the student winners of the International Science and Engineering Fair who traveled to Japan under Operation Cherry Blossom. It turned out to be an excellent choice, enabling the students and their escorts to have a peek at good research, Japanese style.

The Director of the Institute is Fujio Egami, formerly Chairman of the Department of Chemistry at Tokyo University. Dr. Egami, in discussing the direction of the program, says that "the Institute, recognizing the present and future mission and responsibilities of life sciences, aims to contribute to the advancement of the life sciences on the basis of the physical sciences, and to contribute to the welfare of mankind by improvements in medical treatment, environment preservation, and industrial technology." Our host and guide for the visit was Hiroshi Kawamura, a research physician and Chief of the Neurophysiological Laboratory and Physiological Psychology Laboratory. I will discuss his research in some detail later in this paper.

When the Institute was founded, eleven laboratories were established or planned. A brief description follows. The Biopolymers Laboratory studies the chemical nature, action mechanisms, and genetics of pyocin, a product of *Pseudomonas* bacteria. The Biocatalysts Laboratory concentrates on *Thermophile* bacteria, very resistant to high temperatures, which can survive in hot water up to 185°F. The Microbiological Chemistry Laboratory studies the evolution of micro-organisms and applied microbiology. Gene surgery is being planned as a future project. The Cell Biology Laboratory is concerned with the genetics of cultured cells of insects (Drosophila) and mice, wherein gene materials are studied. The Developmental Biology Laboratory carries out research on regulatory mechanisms in the development of the animal body (ontogenesis) using hamsters, mice, and *Xenopus*. The Neurophysiology Laboratory studies the neural mechanisms underlying animal behavior, operant conditioning of vertical eye movements in the midpontine pretrigeminal cat, neural mechanism of the circadian rhythm of the rat, and cockroach olfaction and pheromone. The work of this laboratory will be discussed in more detail below. The Neurochemistry Laboratory deals with the excitable membrane of neuroblastoma cells cultured in *vitro*. The Social Life Science Laboratory is involved with the assessment of life science technology, relation of life science to human welfare, and the evaluation of life science research. The Biochemical Laboratory works on the preparation of new biopolymers with biological activity and the investigation of

their structure and function. Emphasis is on ribonucleases. The Organochemical Preparation Laboratory carries out a search for new biologically active substances, currently studying gramicidin S, nitrobenzene derivatives, and cockroach pheromone. The Director's Group carries out preliminary research in biochemistry. Areas found to hold potential for further study are turned over to one of the other laboratories.

In addition to these eleven original laboratories, four new ones are in some stage of operation: Biophysics, studying muscle mechanisms; Pharmacology, dealing with smooth muscle contraction and drugs; Biogeochemistry, concerned with the changes of various metals in the soil; and Physiological Psychology, studying sleep mechanisms, learning, and memory. This latter laboratory appeared to be just gearing up at the time of our visit. Working there was a recent Ph. D. from the University of Utah, Makoto Sakai, who was conducting research which he describes as follows:

"Recently there has been a revival of interest in selective attention. This psychological process might be best illustrated by an organism receiving several stimuli of the same modality and trying to select one of them in order to respond. What is the neuronal basis of this stimulus selection phenomenon? Over a decade or two a host of reports have suggested that the level of attention to a stimulus can be reflected especially in the amplitude of its cortical evoked potentials in the freely moving animal. One might think that a promising clue to the question is at hand. However, the matter is not so simple. That this might be modified by the prerecepter mechanism such as head or ear movement makes it difficult to consider the amplitude change simply as a functional modification of the sensory system due to attention.

Several reports have recently suggested that this obstacle might be overcome if one studies the evoked potentials to a direct electrical stimulation of the sensory pathway under the condition when the animal pays attention to a stimulus mediated by the same pathway. This technique may be very useful for answering this type of question not only because it eliminates a possible contamination of the prerecepter variable in the evoked potential amplitude, if external stimulus conditions are kept relatively constant, but also because it probably allows us to have a simpler and easier access to the understanding of the amplitude changes at a neuronal level.

Thus, one of the most appropriate methods for investigating the neuronal basis of selective attention would be, as is the case illustrated above, to record two discrete evoked potentials simultaneously by electrical stimulation of two different parts of the same sensory pathway, where one of the stimulated parts is responsible for mediating the sensory stimulus to which the animal's attention is directed.

I have looked for some mammal that is equipped with such a sensory pathway as to satisfy the requirements above mentioned. Considering histological and behavioral evidence, I came to the conclusion that the primary visual pathway of the albino rat would be a prime candidate. Accordingly, I have investigated the distribution of the evoked potentials in the primary visual pathway when either the left or the right optic tract was electrically stimulated, and also the interaction of evoked potentials when both tracts were simultaneously stimulated. I found out that two evoked potentials, one each from the left and right visual cortices, could be recorded simultaneously without any interference with each other.

My next problem was how to train the rat to pay attention to the stimuli coming from one eye, ignoring those coming from the other eye. I managed to establish this situation by suturing the eyelid of one of the rat's eyes so that under this condition the animal could recognize light but not a pattern stimulus through this eye. Then I trained the rat to discriminate the two pattern stimuli, horizontal versus vertical lines through the other normal eye. After the animal fully became able to perform the task, he was implanted with electrodes in the optic tract and visual cortex both in the left and right hemispheres. Then recording of the evoked potentials from both sides of the visual cortex was made by stimulation of the left and right optic tracts simultaneously during the time when the rat performed the task.

One of the interesting findings was the selective potentiation of the amplitudes of evoked potential recorded from the visual cortex into which stimuli for discrimination were fed. At present, I have been investigating the physiological mechanisms underlying this potential."

The feeling is that this laboratory will overcome the isolation deficits of most physiological psychology laboratories in the universities and benefit by contact and interaction with biomedical researchers operating in close proximity.

As our host for the visit was Dr. Kawamura, Chief of the Neurophysiology Laboratory, it was only natural that we spent somewhat more time looking at the work going on there. In a study of the "Operant Discriminative Conditioning of Vertical Eye Movements in the Midpontine Pretrigeminal Cat," Kawamura and his associates presented data of operant conditioning from a yoked control test as well as operant discriminative conditioning. He cited a clinical finding in human patients with bilateral basal pontine infarction whose motion was limited to vertical eye movements and who could communicate intelligently using this medium. The experiment undertaken is cited as the counterpart of this condition in the experimental animal, e.g., the midpontine pretrigeminal preparation. In the acute midpontine pretrigeminal cat, vertical movement, either up or down, and above a set amplitude, was reinforced by introducing an electrical stimulation to the lateral hypothalamic (LHT) reward area. Eye movement noticeably increased during the period of reinforcement. No increase in the eye movements occurred in a yoked control test when LHT stimulation was given to the animal in a fashion unrelated to its own eye movements. On the other hand, the rate of eye movement increased considerably when reinforcement was delivered contingently for each large movement of the eye. In an operant discrimination between S+ (light-off or light-on) and S- (light-on or light-off), the animals developed obvious differential responses to the stimuli. A discrimination reversal of the stimuli was also learned by the cats. When the visual cue was removed, the differential responses during both reinforcement and non-reinforcement periods were eliminated. It strongly appears that in the midpoint pretrigeminal cat a true learned visual discrimination can be achieved. Also, under LHT stimulation an operant conditioning of eye movements occurs without there being any feedback from the peripheral nerves or the caudal central nervous system.

In another study, an "Analysis of Sleep-Wakefulness Rhythms in Male Rats after Suprachiasmatic Nucleus Lesions and Ocular Enucleation," the researchers tried to determine quantifiable characteristics of sleep-wakefulness rhythms in male albino rats. They used long term polygraphic records of EEG activity, neck EMG and EOG which were taken under a 12

hour light, 12 hour dark schedule. Circadian rhythm in sleep-wakefulness disappeared completely after bilateral suprachiasmatic nucleus lesions, without any enhancement of the ultradian rhythms with 2-4 hour periodicity being seen. The circadian rhythm was free-running with a phase shift from -12 to +22 min/day after enucleation of both eyes. Also, there was a gradual decrease of the circadian rhythm spectral value and inverse increase of the ultradian rhythms with 4-7 hour periodicity. In the spectral diagram, paradoxical sleep appeared in both circadian and ultradian rhythms with 4-7 hour periodicity. For behaviourally blind rats with bilateral primary optic tract lesions there was the circadian rhythm in sleep-wakefulness consistent with the normal light-dark cycle of the environment. No characteristic differences were seen for normal rats through power spectral analysis.

THE RAILWAY LABOUR SCIENCE RESEARCH INSTITUTE

Morton A. Bertin

Although the railroads of Japan have since their inception retained an interest in research into the frailties of the human monitor, it took a tragic rail accident in May of 1962, in which 160 people were killed, to stimulate the establishment of an institute incorporating occupational health and industrial psychology under a single organization. The primary cause of the accident was determined to be human error compounded by poor communication in which a trainman ignored a warning signal. Determined to do whatever they could to assure that this would not recur, the railroad decided to merge all the units that were dispersed in various places and to assign support and administrative responsibility to the head office of the Japan National Railways (JNR). Thus, the Institute was conceived and came into being on 1 June 1963.

Almost from the beginning those involved in railroad accident problems recognized that monotony was a pressing and critical factor. Some practical measures have been instituted to provide backup for the human driving the vehicle. In another article in this issue I described the Shinkansen system, but there is a wide network of trains less sophisticated in operation and these too have some fail safe instrumentation. For example, if the trainman does not take some action for 60 seconds, e.g., touch the throttle, brake, signal, etc., a buzzer sounds and a light illuminates requesting a response. If, after a brief period, there is no reaction from the driver, the train is automatically brought to a halt. In any event, it is such and other problems to which the various sections of the Institute address themselves.

The tour of the Institute was hosted by Kazutaka Kogi, a research physician who heads the Laboratory of Work Physiology. Dr. Kogi is also the Chairman of the Editorial Board of the *Journal of Human Ergology*, which is the only publication of its kind in Japan published in English. We began with the Aptitude Test Center, whose activities include developing and administering tests to personnel all over Japan, training the testers, and research on personnel placement. They have branches in five different regional centers. Some of the equipment which I saw and tried out included a reaction time tester for signals, a visual space test, a speed estimation test, a very difficult physical coordination test that was originally designed for aircraft pilots, and a series of intelligence tests. These latter are changed every three years, are being constantly evaluated and validated, and are restandardized every year. As the business of the Institute is accident prevention, it is logical that the ultimate criterion for the validation of the tests administered to the motormen should be the rate of accidents.

The Physiological Research Laboratory, under the direction of Dr. Kogi, is concerned with both experimental and field studies. The first item of interest was a simply simulated train cab for use in a vigilance experiment in which the subject is given a series of signals to which he has to react properly. Physiological measures taken are EEG, heart rate, GSR, respiration rate, EMG, and body movement. Here too the concern is very much with the effects of monotony. Work is also conducted in this laboratory on the design of drivers seats, displays, and controls. Kogi expressed a keen interest in fluctuation of vigilance. He has recorded eye movements and finds that the orientation to the task is less than two minutes. They are studying under which conditions and in which situations vigilance tends to waver.

At the time of my visit, the Occupational Diseases Research Laboratory was undergoing renovation and could not be entered. Their primary function is to accumulate information for measuring the effects of hazardous conditions, the development of early diagnostic techniques, and the study of occupational diseases in general. They are also concerned with maintaining the physical fitness of employees and were about to embark upon a new program to study the effects of a new magnetic system, planned for the future, which will drive the trains at very high speeds. There is an urgent need to determine what effect if any, this system might have on human tissue.

A stop at the Human Engineering Research Laboratory allowed me to fulfill one of the dreams of any red-blooded American boy, to drive a high-speed locomotive. Once inside the cab, with side curtains drawn, the effect was highly realistic and one soon forgot that it was only a simulator, going no place fast. It was of special interest because of my background in aircraft simulators. There is an instructor's console which allows for a dynamic interaction between the instructor and the trainee. The train movement is very realistic with vibration and slight jerking of slowing and acceleration. Sound effects are excellent, one even hears the "whooshing" sounds of the stations flying past. The visual scenery display is also very good and is geared to speed to make a very natural panorama. One is impressed by the complexity of controlling the train; it has always appeared to be such a simple process. I was also given a demonstration of the latest development in automatic ticket purchasing machines. It is a fantastic device that allows the purchaser to select anything he needs for himself and several traveling companions by pushing a few buttons and inserting money into a slot. It should eliminate thousands of jobs, and if the railroad unions have anything to say about it, you will never see it installed in the United States. Next I was shown the data of eye camera recordings of train motormen in which the eye movements were analyzed for the purposes of improving the display systems. One interesting component was a comparison of the eye movements recorded on an actual run and those taken in the simulator, the eye movement patterns being about the same.

At the time of my visit, the Psychological Research Laboratory was conducting experimentation to select optimum color combinations for railroad marking displays. They were showing variously colored automobiles in a device which allowed very slight changes in the combinations to find the most acceptable shadings. Other work being carried out in this laboratory includes doing case studies of accidents and studying accident-prone employees, work satisfaction, and the acceptability of environmental factors. There is also a Social Psychology Laboratory which looks into job supervision, training for accident prevention, and effective train scheduling. They also administer a variety of questionnaires to passengers and workers and conduct attitude surveys and opinion polls.

Kogi talked about some of the research in which he and his colleagues have recently been engaged. In a study of "Monotony Effects of the Work of Motormen During High-Speed Train Operation," they attempted to look at the physiological aspects of the task of driving a locomotive by comparing data from 1965, 1966, and 1972 of the workload of motormen operating trains with top speeds of 210 km per hour. During the year of 1965 the top speed of a 515 km section was 4 hours, and this was lowered in 1966 to 3 hours 10 minutes. For 1965 the mean heart rate was maintained around 80 beats per minute but for the later periods (1966 and 1972) the rate gradually declined. Constant high speed operations in 1966 seemed to stimulate cerebral activities, whereas by 1972 the drivers showed

decreasing perceptual and choice reaction capability. In a subsidiary task, acoustic signal detection, there was a significant error rise. Based upon polygraphic recordings, made in 1972, it appeared that there occurred short periods of drowsiness, an error increase, absence of controller activities, and a temporary drop in heart rate. The fact that these increased after 90 minutes of driving leads to the need to reduce monotony, particularly during periods of underload.

In another related study, they scrutinized the data accumulated from 288 motormen on near accidents. Of 198 near accidents on over 2,290 trips, 34 resulted from some level of drowsing. This appeared to be unrelated to type of train, area, delay, weather conditions, or any factor about the drivers themselves. There were 117 cases related to unexpected obstacles appearing on the track and 47 resulting from such things as poor displays, improper instructions, and equipment failure. One conclusion was that under normal conditions driving at a constant speed induced drowsiness and this was related to fatigue and time of day, as 79% occurred between the hours of midnight and 6 A.M. Interestingly, during the second night of the shift, most drowsing occurred during the period between the second and fourth hour on duty. Kogi concludes that "as monotonous work combined with insufficient sleep seems to play a vital role in causation of drowsiness in traffic, in addition to the influence of general alertness changes by circadian rhythms, it will be important to examine monotonous operation cycles, to avoid driving at night, and to improve rotation systems." It appears to hold implications for other tasks as well.

TOMORROW'S TRAINS ARE HERE TODAY, OR A VISIT TO THE SHINKANSEN CONTROL CENTER

Morton A. Bertin

The writer can personally attest to the comfort and reliability of the Japanese railroad systems, and the Shinkansen is the elite of the lot. The so-called bullet trains are a familiar sight and experience to travelers in Japan, futuristically designed in streamlined cream and blue, traveling at high speeds, rarely delayed, and almost always spotless. They leave Tokyo with great regularity and one wonders about their excellent safety record, considering the constancy of high speed traffic and the possibility and potential for disastrous human error. Many of our questions were answered during a recent visit accompanying the Operation Cherry Blossom student winners to the Control Center.

Some appropriate statistics: The entire line from Tokyo to Hakata extends 1,069 km in length, the last link having been completed and put in operation in March of 1975. There are 28 stations serviced by two types of trains, the Hikari, a super express which stops at only primary stations, and the Kodama, the limited express, which makes all stops. Both trains are just about identical, consisting of 16 cars each. The 165 sets of trains comprising the Shinkansen make 275 scheduled runs daily. Total number of employees are some 16,000 with 70 manning the Control Center. In 1975 approximately 430,000 passengers were carried daily, the one billionth passenger having boarded during May of that year. In a single day, May 5, 1975, over one million passengers were carried over the system. The seating capacity for the Hikari is 1,342, for the Kodama 1,483.

The Control Center is the heart of the Shinkansen system and the Centralized Traffic Control is the brain of the Control Center. In order to assure the safety of operation of this complex system which hurdles hundreds of trains daily through the Japanese countryside, an automatic train control system (ATC) was developed and is supported by COMTRAC, a computer-aided traffic control system, which essentially allows for centralized, almost instantaneous, long distance inputs from the control to the vehicle. It is a fascinating experience to enter this large room and watch the process operate in real time, realizing that the man at the panel is controlling the trains which appear as colored lights showing precise location and movement. Also being automatically controlled are the towers which provide the signals to the motormen. There is a train recorder which notes the movement of each train, and the dispatchers have laid out before them the entire line in dynamic operation. There is constant communication between dispatcher and trainman or conductor with information and instructions being transmitted back and forth. Coded colored lights signal a variety of conditions, abnormal situations resulting in immediate reaction from the controllers.

The trains operate at three variable speeds of 210, 160, or 30 km per hour, depending upon conditions. Controls will reduce or increase speeds depending upon the distance between the trains. The motorman has some control and can reduce speed manually, but if one train approaches too closely to another, it will automatically be slowed or brought to a stop. As the train approaches a station the speed is automatically slowed to the 30 km speed

whereupon the motorman takes over, applying the brakes to bring the train to a halt. Each train carries two men in the cab, persumably an additional fail safe system. In the event of an earth tremor, the intensity will be recorded on seismometers set all along the line. Readings of any tremor of an intensity above three on the Japan scale will automatically cut off power to the area until inspection teams have had the opportunity of inspecting the track for possible damage.

The dispatchers watching the entire line also receive information on the condition of the track, and where it is considered less than optimum, the speed is automatically reduced from the control as the train passes over that stretch. The motorman is contacted and informed why the controls were applied. Wind velocity is also taken into consideration, particularly when the train is on a bridge or in an area where high winds might pose some threat. Under such conditions, when the wind reaches a speed of 30 meters per second, the train is immediately brought to a halt from the Control Center. Levels of water rising in tunnels are also automatically measured to warn of impending danger. In the event of an extremely abnormal situation or if the computer should malfunction, the system can be controlled manually.

The group had the benefit of a thorough briefing by the Chief Dispatcher, who explained the total operation, touching upon what appeared to be the important details. Immediately after the tour of the Center, the students and their escorts left by Shinkansen for Kyoto, undoubtedly with a greater understanding and appreciation of their transport system than most of the other passengers.

THE DEPARTMENT OF PSYCHOLOGY AT NIHON UNIVERSITY

Morton A. Bertin

Reported to have the largest student enrollment of any university in Japan, Nihon appears to be engaged in an on-going expansion program, with buildings in various stages of construction scattered around the campus. The Department of Psychology has the distinction of being the oldest of any private university in the country and is celebrating its 52nd year. My host for this visit was Masaaki Asai, Chairman of the Department, about to leave on a sabbatical for research in United Kingdom. It was arranged for me to meet individually with several of the faculty, to talk about their research interests.

Masao Omura is primarily concerned with the study of anxiety and the standardization of personality tests. One test which he has used extensively is the Manifest Anxiety Scale, which he has been attempting to standardize using Japanese students and defense cadets. Four years ago, while on a sabbatical in the United States, he administered the scale to American students and found significant differences between them and the Japanese sample.

Kohei Ando is said to be one of the leading experts in measurement evaluation and psychological testing. A more recent interest is in the psychology of aging. At present, he and two of his associates, Ken Okamoto and Tadafumi Seki, are studying achievement of Japanese students. There are about 30 high schools attached to the university and the students of these schools are tested periodically in the hopes of developing a procedure for predicting successful performance in the university. This is an ambitious longitudinal study which also scrutinizes other information about the students over the entire span of high school, including scholastic records and teacher evaluations. The program is in its sixth year and its ultimate aim is to be able to eliminate the so called "examination hell" which confronts most students seeking admission to the schools of higher education. The examinations are in Japanese language, English, and mathematics. Data from about 25 thousand students are processed through the computer yearly to tease out any significant factors. To this point they have determined that these achievement tests and the high school records both correlate highly with the entrance examinations.

Masaaki Asai, in addition to being Chairman of the department, is also Vice Director of the Computer Center and has the responsibility for teaching experimental psychology and statistics. He has spent considerable time in the United States and has worked with Osgood and McGinnies on various projects. A primary interest lies in cognitive structures and its relationship with intermodal sensory systems. His hypothesis is that one's cognitive structure has a close relationship with one's linguistic structure. He has extended the semantic differential to the olfactory and visual systems and found the existence of a group of factors common to different sensory modalities. His interpretation is that there is a relationship across modalities to some deeply rooted linguistic structure.

A more recent interest is in traffic prevention and he is an active member of the International Organization of Safety and Traffic Sciences. In addition to developing measures of driver competence, he is establishing an information retrieval system accumulating data on safety and traffic, collating all data emerging from the studies under organizational support.

He has responsibility for the Japanese sources. He would like to see this expanded on a greater international scale and he is involved in some cross-cultural studies of safety and traffic research. Asai maintains a general interest in aviation psychology and has had the opportunity of riding several versions of defense aircraft. In his earlier days he worked on seat configuration and panel displays.

Seiichi Hanazawa works in a rather unique field, that of maternity psychology. This was my first exposure to this particular area of research. In any event, Hanazawa is concerned with the attitudes and experiences of pregnant women and the relationship of these to the newborn child; he calls it the psychology of motherhood, and it includes the study of the psychological changes that occur when a woman becomes a mother. To date he has found that either high or low anxiety mothers correlate low with affective quality while the middle group correlates high. Thus, he concludes that the so called "painless" birth presages some hazards for the mother's feeling for the child and that child rearing will pose problems. He feels that some degree of anxiety is beneficial for the future mother-child relationship, a hypothesis he is now attempting to test.

Kiyoshi Yamaoka is a physiological psychologist whose primary research has undertaken to develop relationships between EEG and a variety of factors. Over the years he has used the EEG to study such areas as visual image (which he calls an inquiry into the color sense process), the hypnotic state, visual perception, Yoga meditation, reaction time, phono-stimuli, mental imagery, and a host of others. He has even studied EEG changes under the effect of "choking," a trick used in Judo to render one's opponent unconscious by oppression of the carotid artery. For subjects, he was able to somehow convince three naive (untrained) students to go up against six rank-holding Judo wrestlers. It appears that with the loss of consciousness theta waves predominated with diffused high voltage delta bursts appearing periodically. With recovery of consciousness slow voltage alpha waves appeared irregularly. In general, the naive students exhibited the same patterns as the experts, though there were individual differences for both groups.

A brief courtesy call was paid on Shotaro Tsumakura, a psychologist who has moved up to be Dean of the College of Arts and Sciences. He would like to institute a cooperative program with several American universities for the purpose of exchanging students, doing joint research, possibly interchanging faculty for brief periods, in fact any areas where a joint effort might enhance the operation of all concerned. This will be explored more fully at a later date.

THE INDO-EUROPEAN IMPACT ON JAPANESE MYTHOLOGY
A REVIEW OF SOME RECENT RESEARCH

C. Scott Littleton

Until recently, any suggestion that the ancient Indo-European speaking mythological tradition might have had an impact on Japanese mythology would have been rejected out of hand by most anthropologists, folklorists, and historians. Indeed, the profound linguistic and historical differences between Japan and the Indo-European speaking West have heretofore precluded any serious challenge to the generally held assumption (e.g., Sansom 1967:26) that there was no connection whatsoever between the two traditions until relatively modern times, that is, until the arrival of the Dutch and Portugese in the 16th century A.D.

To be sure, the fact that certain important Japanese myths, such as Inzanagi's descent to the underworld in a vain attempt to rescue his consort Inzanami[1] and the Sun Goddess Amaterasu's famous sojourn in the cave of darkness, which caused the crops to wither and die,[2] broadly resemble the ancient Greek traditions surrounding, respectively, Orpheus and Persephone has occasionally been noted (e.g., Saunders 1961:420, Sioris 1970, Yoshida 1973). But similar stories can also be found in a number of otherwise unrelated traditions in North America (cf. Hultkranz 1957) and Oceania (cf. Dixon 1964:73-74), and most scholars who have considered the matter (e.g., Sansom, op. cit.) have concluded that these resemblances are the result either of pure chance or some widespread (if not universal) isomorphism among the world's mythmakers.[3]

However, thanks to some recent advances in the science of comparative mythology, both in the West and in Japan, it has lately become apparent that this assumption is incorrect and that an historical relationship of some sort must have occurred at some distant point in the past. For it is now clear that an important structural component of Japanese mythology, especially as expressed in the most ancient texts, the *Kojiki* (712 A.D.)[4] and the *Nihonshoki* (720 A.D.),[5] is remarkably similar to the structure that pervades the myths and epics of the most ancient Indo-European speaking peoples, that is, the Greeks, Romans, Scandinavians, Celts, Iranians, Indians, Slavs, etc. In order to appreciate the full significance of this discovery, credit for which must go to Professor Atsuhiko Yoshida,[6] of Seikei University, Tokyo, it is necessary to review very briefly the salient features of the common Indo-European mythological structure, as it is currently understood.

THE NEW COMPARATIVE MYTHOLOGY

The major breakthrough here was made some forty-odd years ago by the eminent French scholar Georges Dumézil, the founding father of what has since come to be known as "the new comparative mythology" (cf. Littleton 1973). In a brilliant series of books and articles Dumézil[7] has conclusively demonstrated that the Indo-European mythology was structured in terms of three fundamental ideological principles: (1) sovereignty, (2) the exercise of physical prowess, and (3) the maintenance of physical well-being. Expressed in a wide variety of mythological and social contexts, these three principles, or "functions," as Dumézil terms them, served as the framework in terms of which the several ancient

Indo-European speaking communities categorized their divinities. Thus, from ancient India to Scandinavia, one finds triads of gods (or sets of gods), each of which represents one of the three principles. For example, in Vedic India the closely associated divine sovereigns Varuna and Mitra reflected, respectively, the cosmic and social aspects of overlordship, of ultimate order, or *rta*, as it is called in Sanskrit; the great war god Indra personified the exercise of physical prowess, while the twin Ashvina, or "Divine Horsemen," together with the goddess Sarasvati, reflected the "third function," that is, the sum of the processes whereby a community nourishes itself, grows wealthy, and is prepetuated from generation to generation. In ancient Scandinavia the "first function" was represented by the sovereign gods Odin and Tyr, the "second function" by the warlike thunderbolt-hurler Thor, and the "third function" by the rustic Vanir divinities Njordr and Freyr, plus the latter's sister Freya; at Rome the principle of sovereignty was personified by the single divinity Jupiter, physical prowess was incarnated in Mars, and the ideas of physical well-being, fertility, etc., were represented by the agricultural deity Quirinus. In short, although they differed from one another in a great many details, these three mythological traditions, the Indian, the Scandinavian, and the Roman, shared a common ideological heritage, one that permeated their respective world-views. The same basic structure can be discovered in the Celtic, Iranian, Greek, and almost every other ancient Indo-European speaking tradition.

In addition to this tripartite hierarchy of gods, the ancient Indo-Europeans also shared a number of specific motifs and narrative themes. One of these concerns a primeval combat between two classes of gods and/or heroes, one of which represents the first two "functions," that is, cosmic and social sovereignty and physical prowess, and the other reflects the "third function" and a concomitant concern with wealth, sex, and agricultural abundance. The end result of this conflict is the defeat of the "third function" figures and their incorporation into a single albeit functionally differentiated pantheon. The best examples here are the pseudo-historical Sabine War, in which the Romans, led by their primeval king Romulus (here a transposition of the god Jupiter), defeated the wealthy and luxury-loving Sabines after stealing their wives, and the more clearly mythological Norse (i.e., ancient Scandinavian) account of a war between two families of gods, the Aesir (that is, Odin, Tyr, and Thor) and the Vanir (Njordr, Freyr, et al.), in which the latter were defeated and subsequently incorporated into the pantheon. Another, less certain example of this "war between the functions" theme can be found in the *Iliad*, wherein the Greeks seem to reflect the first two "functions" and the Trojans the "third function" (cf. Littleton 1970).

SOME JAPANESE PARALLELS

It is now clear that many of the major figures and events of Japanese mythology can be analyzed in terms of the *same* ideological structure. As Professor Yoshida, who studied with Dumézil in Paris for nine years, now sees it (cf. Yoshida 1974, etc.), the great solar goddess Amaterasu, the divine sovereign par excellence, together with the divinities Takamimsubi and Kamimusubi, reflects the "first function"; her brother Susanowo, whose most striking traits are enormous strength and ability as a warrior, reflects the "second function," and the great agricultural divinity Okuninushi, son of Susanowo, as well as the two princes of Oke, among others, are reflections of the "third function." Indeed, the parallels between the latter pair and the widespread Indo–European traditions relating to the Divine Twins (the Ashvina, etc.) are particularly impressive. Like their Indo-European counterparts, the two Princes are

principally concerned with the promotion of agriculture, and their reigns are notable as eras when peace and prosperity were universal.

Moreover, the theme of a conflict (or at least an amalgamation) between two sets of divinities can be discerned in the Japanese texts, one that seems to parallel the "war between the functions" theme just mentioned. I refer here to the widespread assumption on the part of Japanese scholars (e.g., Takagi 1925) that the traditions preserved in the *Kojiki* and the *Nihonshoki* are the result of an amalgamation of two distinct mythological traditions: that of Takamagahara and that of Izumo. Just as earlier Indo-Europeanists held that the Scandinavian account of the war between the Aesir and the Vanir reflected the superimposition of the Germanic speaking (i.e., Indo-European) tribes upon the indigenous inhabitants of Northern Europe, so it has long been suggested that these two strands in Japanese mythology reflect the fusion of an indigenous tradition (Izumo) with an intrusive on (Takamaghara). But just as Dumézil was able to demonstrate that the Scandinavian conflict myth was not the product of a unique set of historical circumstances, but rather a version of a common Indo-European theme, so it is now possible to suggest that the two apparently distinct Japanese traditions are in fact but aspects of a *single* ideology, one introduced by the intruders (see below).

For example , the Izumo version consistently emphasizes agriculture and related pursuits (that is, "third function" characteristics), while the Takamagahara version emphasizes force and the achievement of sovereignty. Thus, in the Izumo myths about Susanowo his warlike traits are typically subordinated to his otherwise peripheral achievements as far as agriculture is concerned, such as having generated a number of species of fruit trees. The same thing can be said for the other major divinities: the Takamagahara version stresses their "first" and "second function" traits; the Izumo version stresses their "third function" traits.

To be sure, the pattern here is by no means as clear-cut as the one to be found in the Indo-European conflict myths previously cited. Yet the same basic elements are present in both traditions: two apparently distinct communities, one emphasizing overall sovereignty and the exercise of physical prowess (Romulus' Romans, the Aesir, Takamagahara) and the other focusing on agricultural activities (the Sabines, the Vanir, Izumo), amalgamate and form a single community.

Yet another Indo-European theme—heretofore unmentioned—that is reflected in Japanese myth concerns the ambivalent and unpredictable character of the warrior figure. Just as Indra and his "second function" counterparts throughout the Indo-European speaking domain commit a series of "sins" against the sovereign order of things (cf. Dumézil 1970*b*), so Susanowo defies his sister (Amaterasu) and is as recalcitrant and as violence prone as any Indo-European warrior, divine or heroic.

In short, it is now possible to suggest on structural grounds alone that there is indeed a very ancient connection between the Indo-European and Japanese traditions, one that dates back at least to the beginning of the eighth century A.D. and most likely a great deal earlier. And if we add to what has just been discussed the resemblances between isolated motifs in Greek and Japanese mythology mentioned at the outset, the probability of such a connection becomes almost certain.

The exact date and nature of this connection are still not wholly clear, Although Professor Yoshida and his co-workers, among them Professor Taryo Obayashi, of Tokyo University, are now fairly certain that it began shortly after the beginning of the Christian era (that is, in the centuries immediately preceeding the rise of the Yamato clan) and involved a diffusion specifically from the Indo-Iranian speaking nomadic communities of the steppes of what is now South Russia (that is, from the Scyths, Sarmatians, and other related steppe tribes). The intermediaries in this transmission process seem to have been the several Altaic or Turkic-speaking tribes then pushing westward from their homeland in East Central Asia. These Altaic speakers, having picked up the tripartite ideology from their western neighbors, eventually diffused it eastward to Japan via Korea (where it also seems to have left its mark on the local tradition). Indeed, it now appears that the ancestors of the Yamato may well have been Altaic speakers and that the unique character of the Japanese language reflects a synthesis between an Altaic dialect (e.g., Japanese *kuroi*, Turkish *kara*, both of which may be translated by the English word "black") and an indigenous language. Thus, the "war between the functions" theme would have received substantial support from actual historical circumstances and may have served to "explain" the formation of a single Japanese nation in the centuries prior to the compilation of the earliest chronicles.

It should, of course, be emphasized that in the context of this necessarily brief article it is impossible to do more than scratch the surface, as it were, of what is indeed a most complex research problem. Nevertheless, thanks to Professor Yoshida's judicious application of "the new comparative mythology," it is now apparent that the Western impact on Japan, if not vice versa, began almost 1,500 years before the arrival of the Dutch and Portugese and approximately two millennia before Perry's "Black Ships" anchored off Uraga and inaugurated the current phase of Indo-European-Japanese contact

A WORD OF CAUTION

Finally, a word of caution to those who might be tempted to jump to the wrong conclusions.

Despite the obvious significance of this new discovery, a vast gulf still separates the Japanese and Indo-European mythological traditions. Indeed, the differences between these traditions, both in structure and in content, far outnumber the similarities, and as Professor Shigeichi Kure, a leading Japanese Hellenist, has observed, "An apparent likeness is sometimes misleading" (quoted by Sioris 1970:5). Moreover, the Japanese people are *not* Indo-European speakers, nor are they the descendants thereof, and the impact of the Indo-European ideology was, as we have seen, at best indirect.

Yet the very fact of its presence at such an early date in Japanese history somehow makes that gulf seem less vast. And as my colleagues pursue their research, we may eventually come to the conclusion that we are not quite as fundamentally different from one another—at least when it comes to our respective mythologies—as it has heretofore seemed.

NOTES

1 Inzanagi and Inzanami are the primeval couple of Japanese mythology. According to the *Kojiki* and the *Nihonshoki* (see below), after giving birth to the Fire God, Inzanami's

private parts were so burned that she became ill and died. Still in love with his sister-wife, Inzanagi resolved to bring her back from the land of the dead. but Inzanami had eaten the food of the dead and was beyond rescue. Moreover, she was so disfigured by her ordeal that she forbade her brother to look upon her, and when he attempted to do so, she caused him to be driven back to the land of the living.

Inzanagi and Inzanami were the progenitors, directly or indirectly, of almost all of the major Japanese divinties.

2 Born from Inzanagi's left eye, Amaterasu is by far the most important of the primary Japanese divinities. Defied by her brother Susanowo (who was born from Inzanagi's nose), she decided to withdraw from the world and took up residence in a cave. When she did so the sunlight disappeared, and the normal agricultural cycle was profoundly disturbed. She was eventually enticed to come out of her cave by the laughter that greeted a lewd dance by the goddess Ama no Uzume. Upon her reappearance, the regular alternation of day and night resumed, and the land became fertile once again.

3 Or, in the words of Michael Grant (1962:83,104), all major myths may be but ". . . dialects of a single language . . . the Magna Carta of our universe." A similar argument has been advanced by the eminent French anthropologist Claude Levi-Strauss (e.g., 1965, 1966), who asserts that all myths share a common "deep structure," one predicated on the dialectic resolution of otherwise inherent contradictions, such as that between "life" (e.g., Orpheus/Inzanagi; Persephone restored to Demeter/Amaterasu out of the cave) and "death" (e.g., Euridice/Inzanami; Persephone in Hades/Amaterasu in the cave).

It would be impossible here to assess all the pros and cons of the position espoused by Grant, Levi-Strauss, et al., save to say that even if a universal "deep structure" or "language" is in fact present in the world's myths, its presence would not preclude the possibility of isolating–at a more "surface level," perhaps–specific historical relationships of the sort we are concerned with in this paper.

4 I.e., "Records of Ancient Matters." The *Kojiki* is the oldest Japanese book and was ordered complied by the Emperor Temmu (637-686 A.D.). The translation used in this article is by Basil Chamberlain (1906).

5 I.e., "Chronicles of Japan" (sometimes called the *Nihongi*). Covering much the same ground as the *Kojiki*, the *Nihonshoki* is more chronological in organization and betrays a much heavier Chinese influence in its style, etc. The translation used here is by W. G. Aston (1972).

6 Professor Yoshida's most recent book, as yet untranslated into a European language, is *Nihon shinwa to Indo Shinwa* (1974). It is the source of most of the ideas discussed in this paper. Earlier articles by him which bear on the subject at hand are listed in "References Cited" (Yoshida 1961, 1962, 1963, 1965, 1973). I would like to thank Professor Yoshida for his extremely helpful comments and suggestions on an earlier draft of this article.

7 It would be impossible here to list all of Professor Dumézil's major works. Perhaps the most succinct overview of his thesis—as yet little known in the United States, despite the recent appearance of some English translations—is still *L'ideologie tripartie des Indo-Européens* (1958). Other major works by him, as well as the translations just mentioned, are listed in "References Cited" (Dumézil 1941, 1952, 1970*a*, 1970*b*, 1974). For a comprehensive review and analysis of his contribution to comparative mythology, together with a complete bibliography (to 1972), see Littleton 1973).

8 However, in an article now in preparation for publication Professor Yoshida convincingly argues that the "war between the functions" theme can also be seen in the conflict between the heavenly divinities, led by Amaterasu and Takamimsubi, and the earthly ones led by Okuninushi over the cession of the land to the divine ancestor of the Tenno clan (that is, the Imperial House). Eventually, Okuninushi and his third function cohorts are defeated, and the way is paved for the establishment of the Imperial system. However, once the hostilities are over, Okuninushi is restored to prominence in the pantheon and indeed becomes the perpetual protector of the Emperor and his family. As Okuninushi is enshrined at Izumo, there is a close connection between this and the more generalized manifestation of the theme just discussed.

Thus, it now seems that the Japanese tradition did in fact include a canonical version of the "war between the functions," one that more closely approximates the Indo-European them just discussed.

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